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Data on Fish Species from Bering Sea and Gulf of Alaska

Karl Niggol

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DATA ON FISH SPECIES FROM BERING SEA AND GULF OF ALASKA

BY

Karl Niggol

Resource Ecology and Fisheries Management Division
Northwest and Alaska Fisheries Center
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
2725 Montlake Boulevard East
Seattle, WA 98112

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TABLE OF CONTENTS

1. PURPOSE OF THE DATA SUMMARIES

The fisheries ecosystem simulation models require large quantities of fisheries and species specific data as input. These data must be "distilled" and evaluated from a rather large number of published reports, and unpublished data sheets. In the process of this data collection and evaluation, it was found that most of the data were not easily available. Moreover, the quality of data varied considerably, thus requiring considerable analysis and evaluation. Therefore, summarization and consolidation of these data served as the reasons for preparation of this species summary.

The data presented here are mean values for two regions--the eastern Bering Sea and Gulf of Alaska. Biometric characteristics of most species indicate that separate stocks exist in these two regions, although in some species considerable migrations and intermixing between these two areas occur.

2. SOURCES OF DATA AND EXPLANATION OF TERMS

The basic biometric data (age-length, age-weight, and weight-length) were either extracted from published literature, obtained from colleagues in NWAFC, or extracted from Resource Assessment and Conservation Engineering (RACE) Division survey data files or from Resource Ecology and Fisheries Management (REFM) Division.

The biometric data presented in this summary are long-term mean values for two regions: the eastern Bering Sea and the Gulf of Alaska. Length and weight data are mean values for females and males together, assuming a 50-50 sex composition.

A long-term mean age composition of exploitable year classes is required for the computation of biomass and mortality distribution with age. A mean age composition of commercial catches was obtained by adding all available age compositions over a number of years, thus eliminating the effects of strong and weak year classes (Fig. 1A). Furthermore, a "knife edge" recruitment was assumed for the youngest, fully exploited year class (Fig. 1B) . The “tail end” of older year classes, which constitute only minor contributions to catches, was neglected (Fig. 1B). This “tail” presents, in many cases, the survivors of strong year classes.

The younger limits of the exploitable age length and weight given in the species tables depend on the gear used. Further, the oldest exploited age was determined as in Figure 1, neglecting the “tail end.”

The domestic and foreign catches refer mostly to 1980 data which were taken from various internal reports in NWAFC. No “official” catch statistics exist for the NE Pacific Ocean, which would be comparable to International Council for the Exploration of the Sea statistics in the North Atlantic.

Depth distribution of the species and its seasonal limits were taken from available reports and/or obtained from colleagues. Depth distribution of catches refers to present fishing practices. The depth distribution of species varies seasonally and the depths given refer to present knowledge of depth distribution of exploitable stocks.

Age of maturity refers to the age when >50% of the population is mature. The age of maturity is not known for many species. It is known to vary with the growth rate of the species.

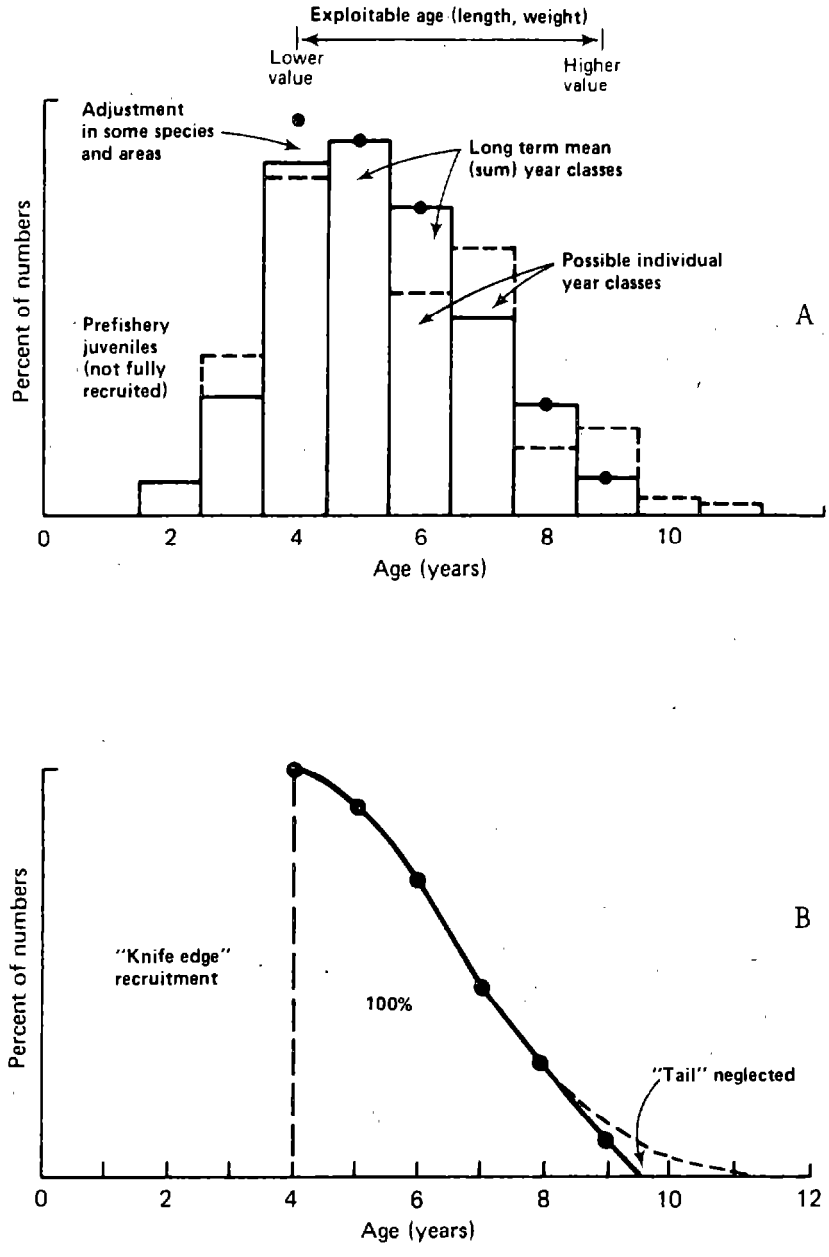


Figure l.--Scheme for determination of long-term mean age composition of fully exploited year classes.

The times of spawning and spawning areas and depths, which vary with locations, are also not known in detail for many species.

The fecundity is a function of size/age of the species and varies somewhat from one region to another.

At the end of the "species tables" qualitative notes on the food composition are given. Quantitative estimates of food composition have been given in ecosystem model input documentations.

Turnover rates refers to the quotient of total annual mortality of biomass by annual mean biomass (standing stock).

Growth rates are given in percent of biomass growth (with reference to the previous months biomass, B_{t-1}).

Condition factor (coefficent) is not computed here. Where it is mentioned in the text, it refers to quotient of weight divided by cube of length.

This summary indicates many shortcomings in available data. It especially points out the need to obtain accurate measurements on representative samples (i.e., purposefully stratified samples), rather than careless measurements en masse.

The Ecosystem Modeling Task would appreciate all comments, corrections, and additions which the users of this memorandum care to make.

3. METHODS USED TO COMPUTE DERIVED PARAMETERS

This data summary contains several derived (computed) quantities, such as biomass distribution with age and age specific total mortality, most of which are necessary for the ecosystem simulation. They have other

uses in fisheries problems as well. The methods (and formulas) of computations -of these parameters are described by Laevastu and Larkins 1981.

The weight at age data are used for computations of growth rates (in weight) . The annual individual growth rates are given in graphical form and the monthly growth rates of total biomass,' juveniles and adults, are given in the table for given annual turnover rate of the biomass.

The distribution of biomass with age for a given turnover rate and the corresponding distribution of total mortality with age (expressed as percent of mortality of the mean biomass at a given age) are given in the graphs. Biomass and mortality distributions also depend on the annual turnover rate. The selected turnover rates are close to those found with Prognostic Bulk Biomass (PROBUB) model.

4. EXPLANATIONS TO TABLES AND GRAPHS

The numerical and graphical data for each species are followed by brief notes on the status of the data and indications of some findings during the preparation of the summaries.

The first, general tables for each species gives a variety of estimated data for each of the two regions (eastern Bering Sea and Gulf of Alaska); exploitable age, length, and weight; domestic and foreign catches; depths of distribution and fishing; age and length at maturity; spawning season and areas; and fecundity.

The following values are computed at given turnover rate: percentage of exploitable and juvenile biomasses, monthly growth rates (in percent per month of the biomass present) of whole biomass, and of juvenile, adult, and deceased fractions of this biomass.

Finally, qualitative notes on principal food components are listed.

The first graph is age-length relation (assuming a 50-50 sex composition), followed with tabular data of the same. The second graph is length-weight relation, followed with a table, and the third is age-weight relation, followed again with a table. The fourth graph is the age composition of the fully exploited year classes (number based), normalized to knife-edge recruitment.

The following three graphs are derived (computed) quantities: growth rate in percentage per year of the mean biomass of the year class, distribution of total biomass with age (in percentage of total), and total mortality of individual year classes expressed as percentage of mean biomass of the same year class. Obviously this value can exceed 100% in year classes where the growth rate is above 100%. These two last graphs pertain to a given turnover rate, which is indicated on the graph.

5. DATA ON COMMERCIAL SPECIES

5.1 WALLEYE POLLOCK (Theragra chalcogramma)

Due to variability in data, no interannual changes of growth rate can be observed. There is also considerable uncertainty in the meager data available on age and size at maturity.

No essential differences in length and weight at age can be observed between the Gulf of Alaska and the Bering Sea. (That the fish in the Bering Sea might grow slightly faster as juveniles, might be due to greater abundance of euphausiids in this area.)

The data do not allow any conclusion of separate stocks occurring in the two areas; some data indicate that there is considerable intermixing of pollock between the Gulf of Alaska and the Bering Sea. (There is an accumulation of older specimens in colder areas in the Bering Sea. The higher total mortality in the Gulf of Alaska of fish 5 to 8 years old might indicate emigration to the north.)

The fish in the Bering Sea come under full exploitation one year earlier than the fish in the Gulf of Alaska.

The relatively long “tail end” in long-term mean age composition of catches indicates that the stock had not been fished heavily in the past.

WALLEYE POLLOCK (Theragra chalcogramma)

	Gulf of Alaska	Bering Sea
Exploitable - age (years)	4-11	3-11
length (cm) [1/]	35-60	30-60
weight (g)	350-1400	200-1400
Catches - domestic (t)	1100	10,500
foreign (t) [2/]	110,000	1,006,OOO
Depth - distribution (m) [3/]	30-2000	5O-2000
fishing (m)	100-200 winter 5O-150 summer	90-300
Maturity - age (years)	3	3
length (cm)	30	30
Spawning - season	March to June	March to July
area	Between Kodiak Isl. and mainland (Shelikof Strait)	All over E. Bering Sea (major spawning in SE Bering Sea)
Fecundity	29,000 to 169,000	186,000 to 600,000
At a turnover rate of .65		
Exploitable biomass,%	63.1	74.8
Juvenile biomass,%	36.9	25.2
Growth rate, % per month		
Whole population	4.0	4.0
Juveniles	7.4	8.6
Adults	2.00	2.5
Deceased	5.2	5.1

Notes on food composition: Most important food items - euphausids, copepods, young pollock, shrimp, crab, other fish, and amphipods.

[1/] Major year classes exploited

[2/] Provisional estimates for 1980 (Murai et al. 1981).

[3/] Pelagic over deep water

AGE-LENGTH-WEIGHT KEY

Pollock (Theragra chalcogramma)

Age	Bering Sea Length[1/] cm	Bering Sea Weight[2/] g	Gulf of Alaska Length[3/] cm	Gulf of Alaska Weight[4/] g
1	15.3	32.0	15.0'	28.0
2	25.1	130.0	25.0	118.8
3	32.4	252.0	33.0	223.0
4	38.6	425.0	38.8	399.0
5	43.6	614.8	43.1	581.8
6	47.5	781.3	46.4	737.5
7	50.2	911.6	49.3	873.8
8	52.7	1035.3	52.0	1002.0
9	54.8	1154.3	54.2	1105.0
10	56.5	1265.2	56.4	1205.0
11	58.4	1380.0	58.1	1320.5
12	59.8	1480.5	59.6	1418.4
13	61.2	1565.0	60.6	1505.5

1/ Smith, 1979; Pereyra et al. 1976; Observer Program.

2/ Smith 1979; Pereyra et al. 1976; Observer Program

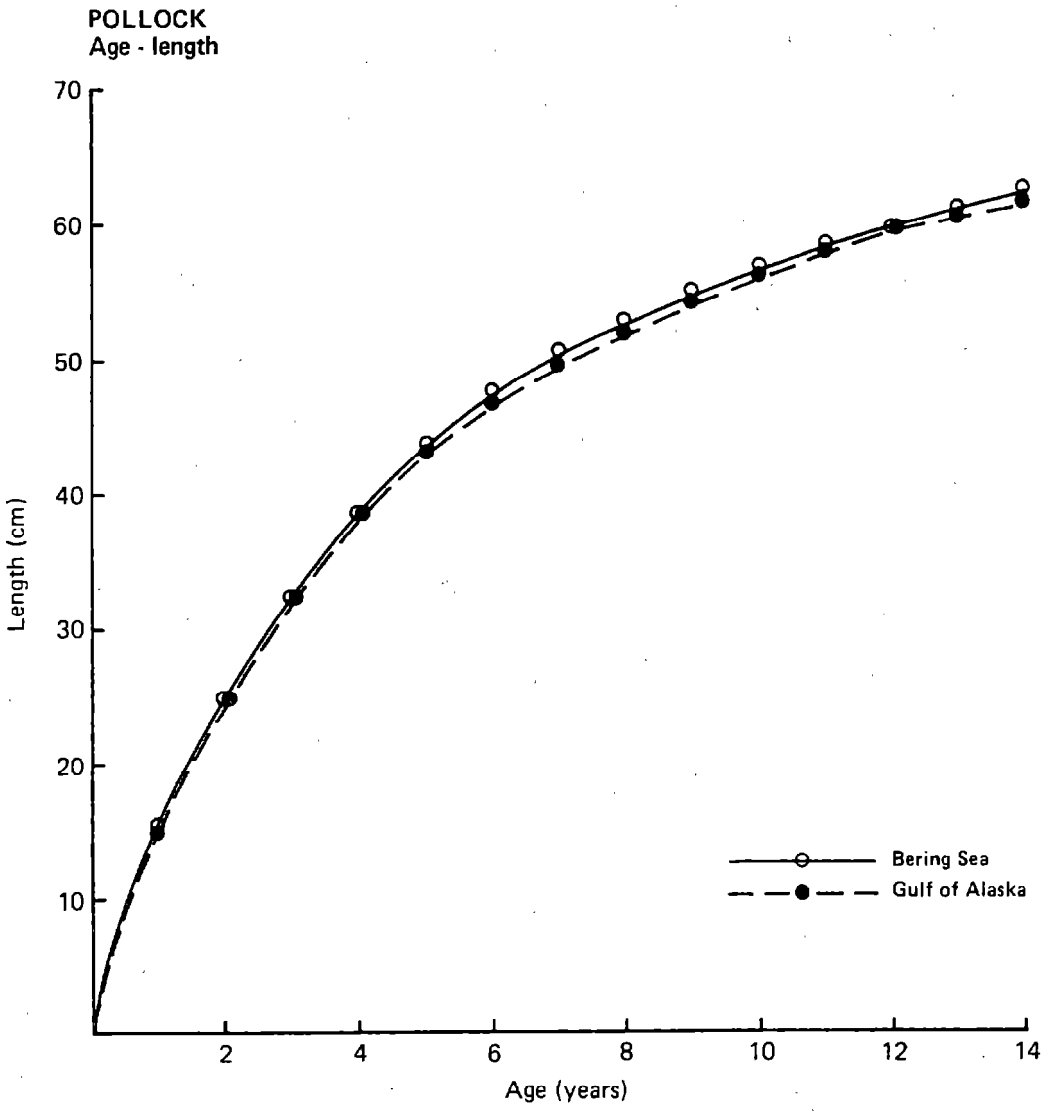
3/ Ronholt et al. 1978; M/F cruise 1978/3; Observer Program.

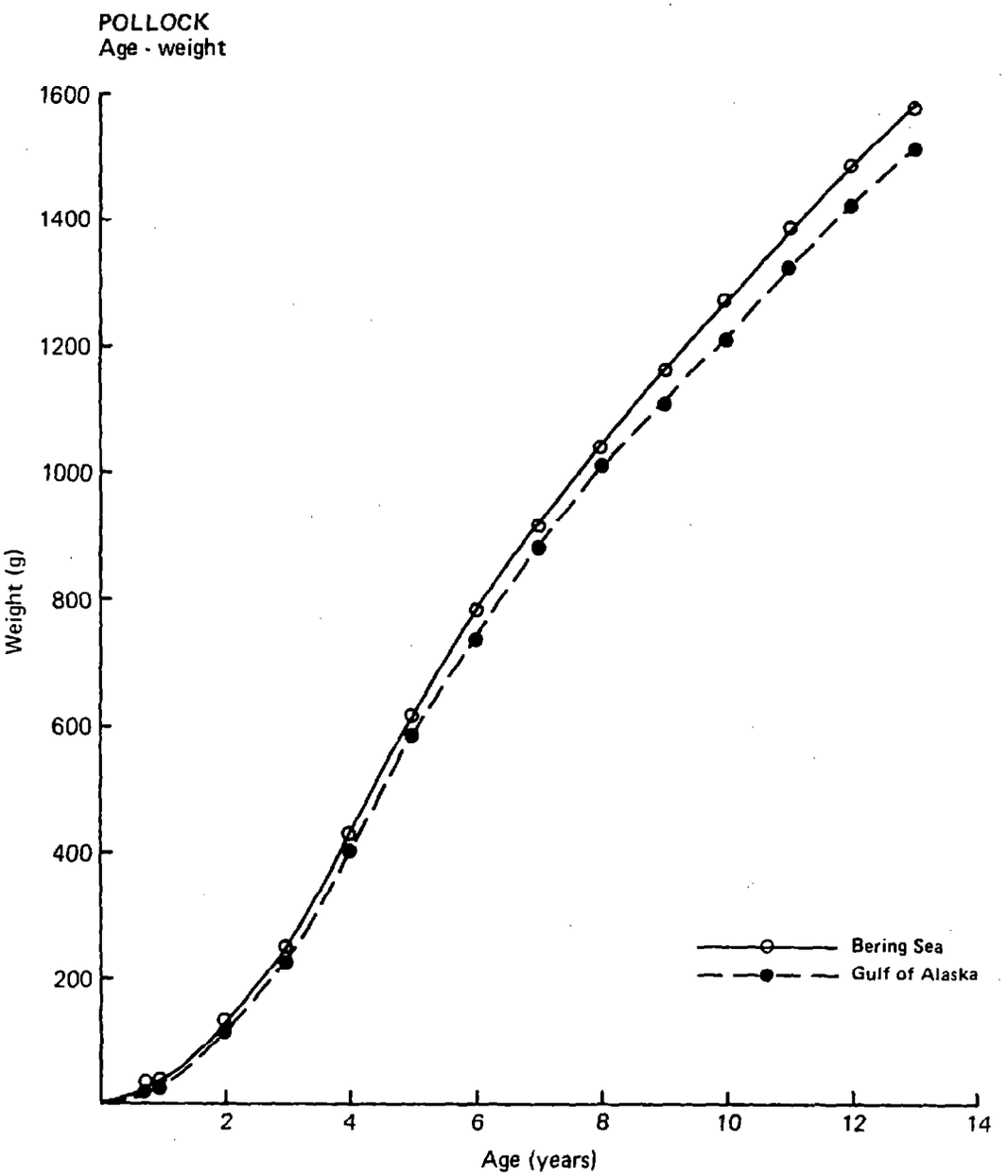
4/ Ronholt et al. 1978; Observer Program; Calculated from age-weight data.

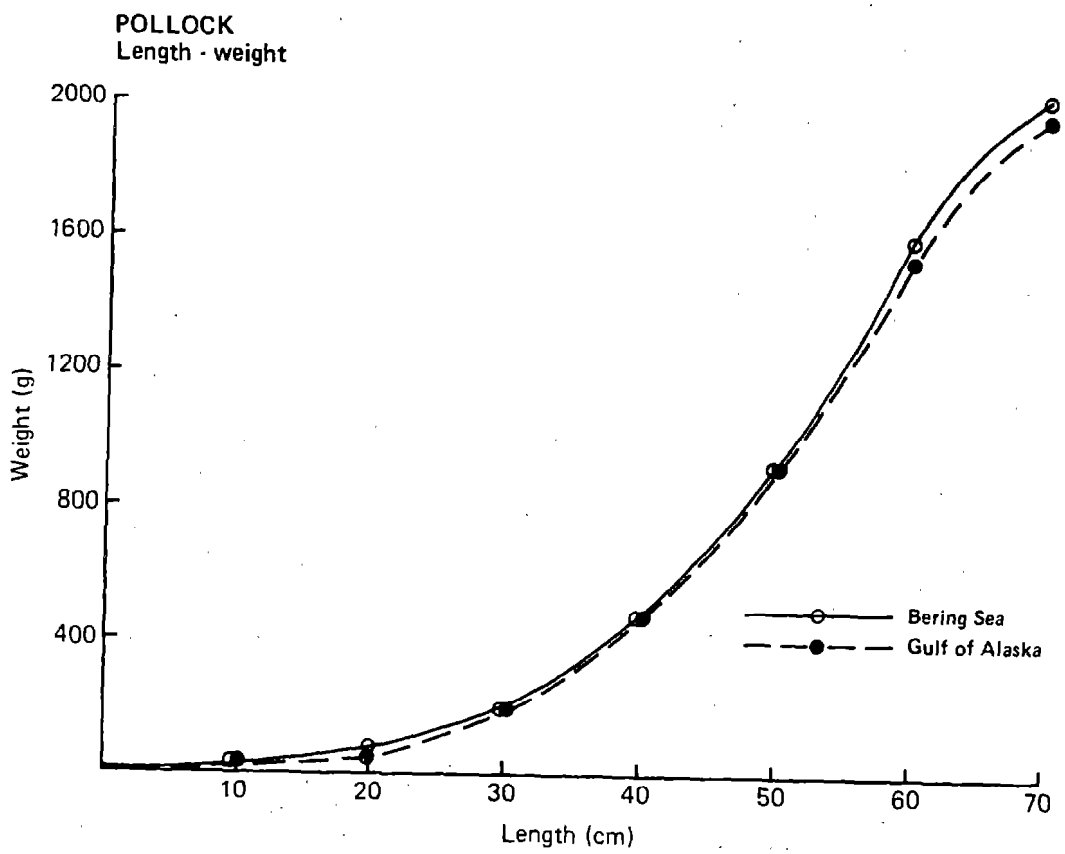
LENGTH-WEIGHT KEY
Pollock (Theragra chalcogramma)

(Calculated from age-length and age-weight data)

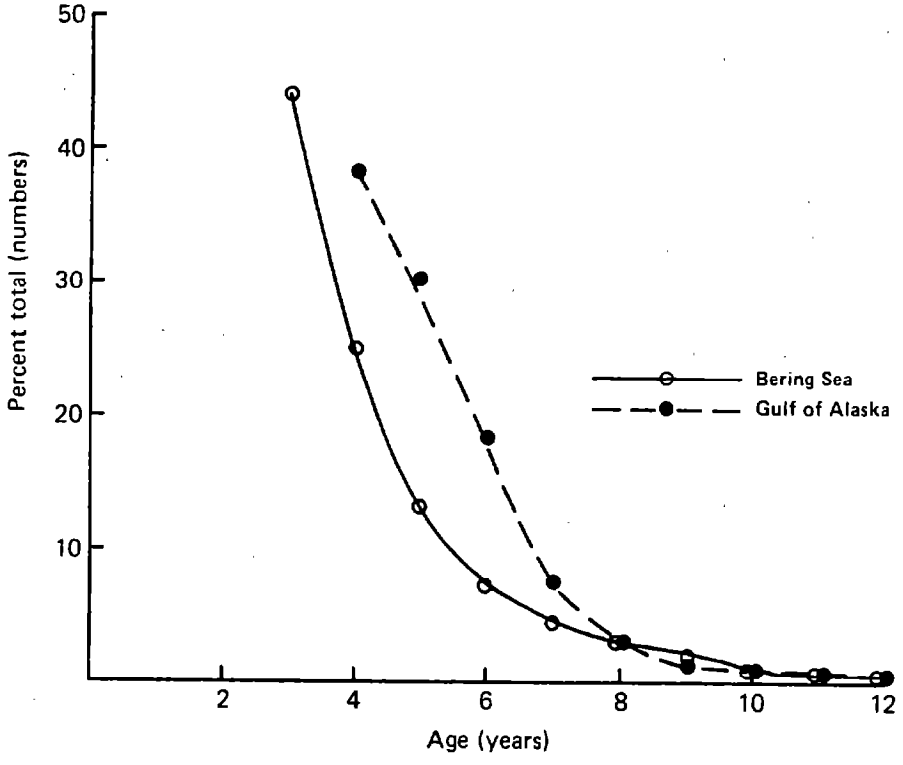
Length cm -	Bering Sea Weight g	Gulf of Alaska Weight g
10	12.5	11.9
20	72.5	60.0
30	200.0	198.5
40	475.0	455.0
50	915.0	905.3
60	1475.0	1520.0
70		1950.0

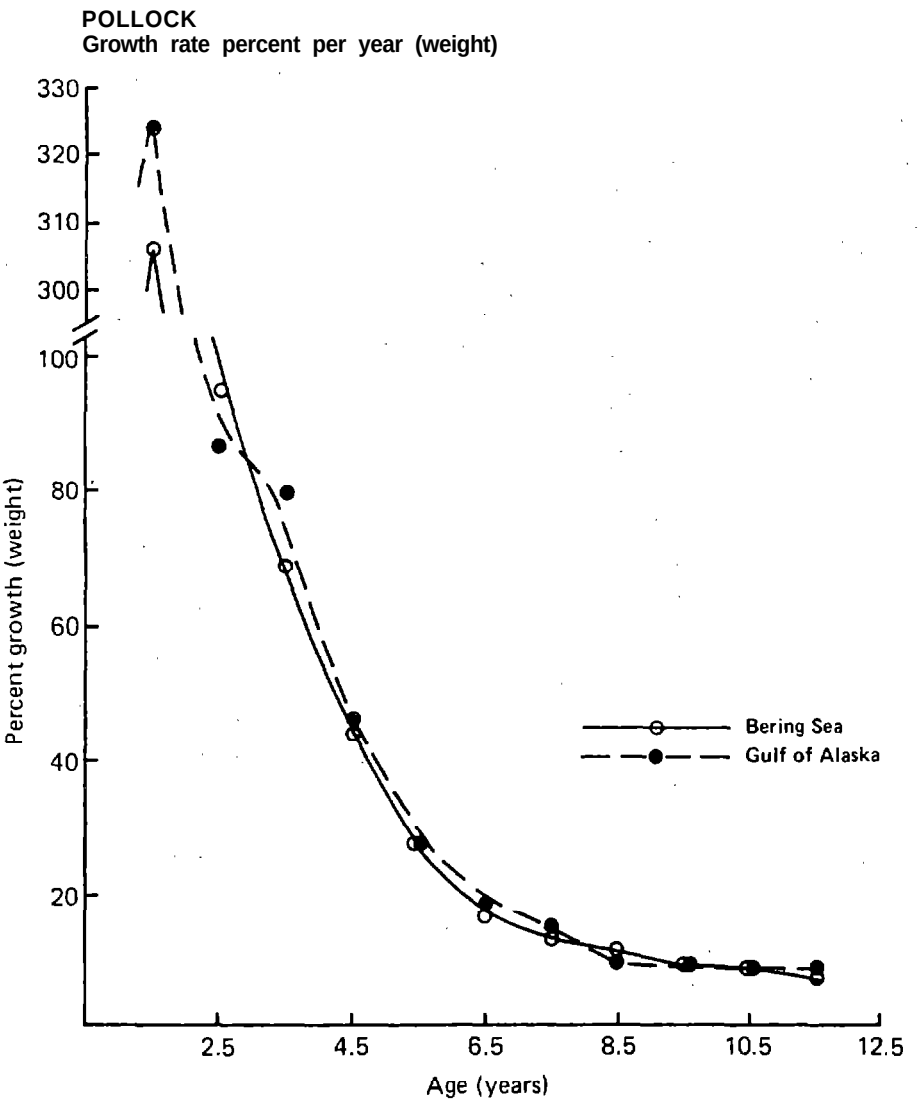

POLLOCK
Age - length
70
60
50
40
30
20
10
Length (cm)
2
4
6
8
10
12
14
Age (years)
Bering Sea
Gulf of Alaska


POLLOCK
Age - weight
1600
1400
1200
1000
800
600
400
200
Weight (g)
2
4
6
8
10
12
14
Age (years)
Bering Sea
Gulf of Alaska

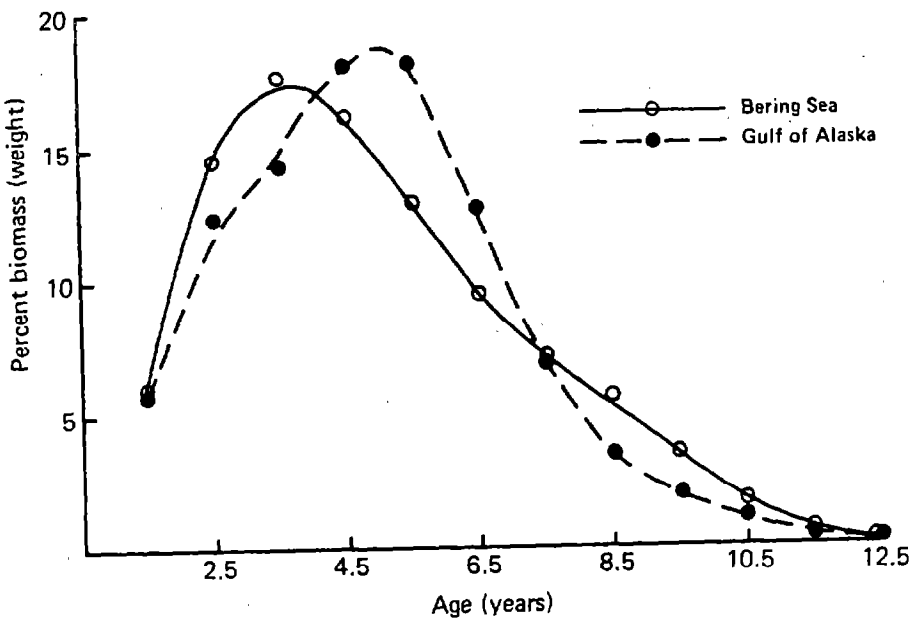

POLLOCK
Length - weight
2000
1600
1200
800
400
Weight (g)
10
20
30
40
50
60
70
Length (cm)
Bering Sea
Gulf of Alaska

POLLOCK
Long term mean age composition of fully exploited year classes

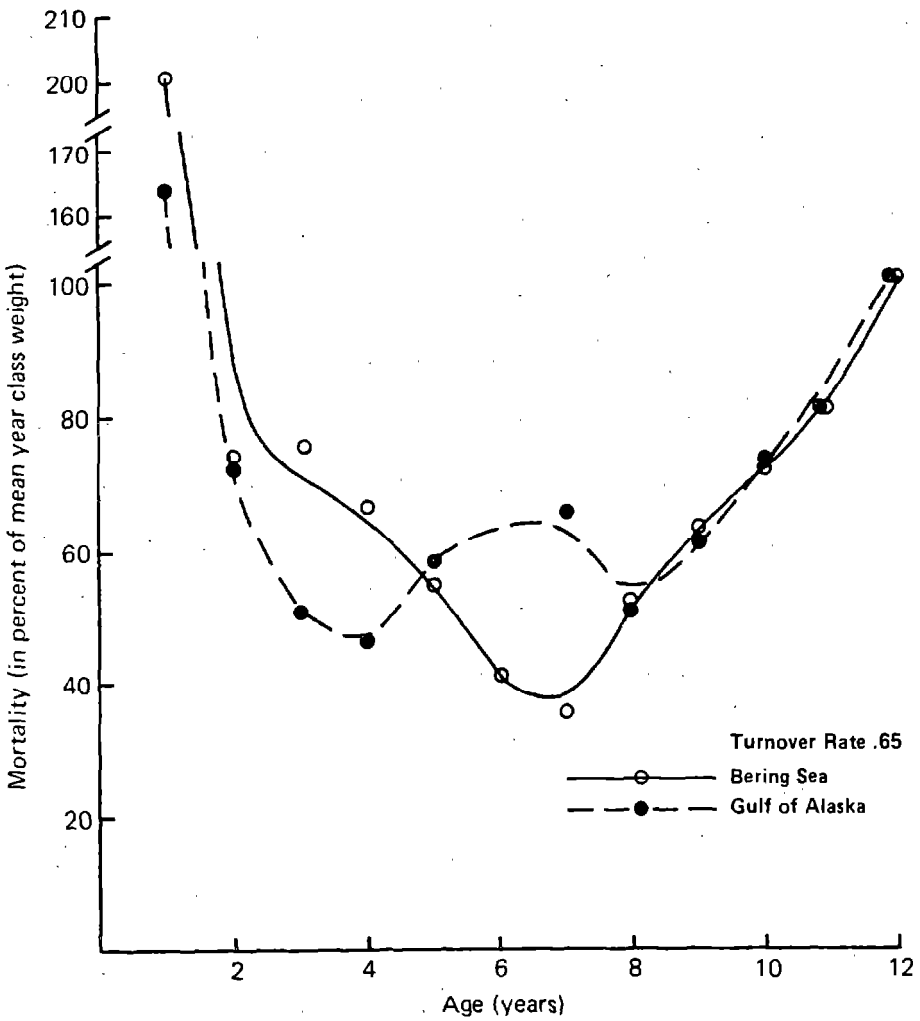



POLLOCK
Growth rate percent per year (weight)
330
320
310
300
100
80
60
40
20
Percent growth (weight)
2.5
4.5
6.5
8.5
10.5
12.5
Age (years)
Bering Sea
Gulf of Alaska

POLLOCK
Distribution of biomass with age



POLLOCK
Distribution of mortality with age of mean year class biomass



5.2 PACIFIC COD (Gadus macrocephalus)

The growth rate of Pacific cod in the Gulf of Alaska (mainly in Kodiak area) is considerably faster than in the Bering Sea, indicating the existence of separate stocks. (However, there might be some mixing of the stock in the western Gulf of Alaska with Bering-Sea stock via Aleutian passages. This conclusion is partly supported by the variable age-length, weight data, especially as reported in literature.) The variations in available biometric data might also indicate problems with age de termination.

The long-term mean age composition of fully recruited year classes (based on rather meager data) indicates that younger year classes (3 and 4) are over-represented in the catches compared to expected normal age distribution. of slightly fished stock. This might be caused by different depth distribution (and consequent different availability to fishery) of different age groups, as it is known that older cod seek deeper depths.

Maximum biomass of cod occurs at medium ages (3.5 to 4.5 years) due to the rapid growth of this species.

PACIFIC COD (Gadus macrocephalus)

	Gulf of Alaska	Bering Sea
Exploitable - age (years)	3 to 8	3 to 8
length (cm)	40 to 85	40 to 85
weight	0.75 to 6.5	0.75 to 6.0
Catches - domestic (t) 3/	500	8,500
foreign (t) 3/	34,000	37,000
Depth - distribution (m) 1/	100 to 400	100 to 400 (W) 1/ 20 to 400 (S)
fishing (m)	80 to 260	80 to 300
Maturity - age (years) 2/	3	4 ?
length (cm) 2/	50	50
Spawning - season	Jan to March	Jan. to May
area	Along cont. slope of Alaska Penins.	?
Fecundity	0.86 to 3 million	1 to 2 million
At a turnover rate of .90		
Exploitable biomass, %	64.1	67.0
Juvenile biomass, %	35.9	33.0
Growth rate, % per month		
Whole population	5.2	5.2
Juveniles	10.2	9.4
Adults	1.4	3.1
Deceased	7.0	6.00

Notes on food composition: Most important food items - shrimps, herring, sandlance, flatfish, crabs, euphausids, and Atka Mackerel (Andreyasheve, 1937).

1/ Some cod is assumed to be pelagic over deep water.

2/ Age and length when 50% of the population-matures.

3/ Provisional estimates for 1980 (Murai et al. 1981).

AGE-LENGTH-WEIGHT KEY

Pacific cod (Gadus macrocephalus)

Age	Bering Sea		Gulf of Alaska	
	Length[1/] cm	Weight[2/] g	Length[3/] cm	Weight[4/] g
1	27.5	185.0	28.5	275.0
2	43.0	600.0	47.0	1050.0
3	53.0	1200.0	58.0	2100.0
4	62.0	2200.0	66.0	3150.0
5	68.5	3150.0	73.0	4370.0
6	74.5	4170.0	78.0	5220.0
7	80.0	5150.0	82.0	6050.0
8	84.5	(6075.0)	85.5	(6750.0)

1/ Research and commercial vessel data 1977-80 (Bakkala, 1981, unpublished); Japan-US Summary Report (unpublished) 1980; Pereyra et al, 1976; Kibesaki 1965; Observer Program 1976-1979; RACE data 1981 (sample size 3393).

2/ Calculated from length-weight data.

3/ Ronholt et al. '1978; Observer Program 1977-79; RACE data 1981 (sample size ‘4886)

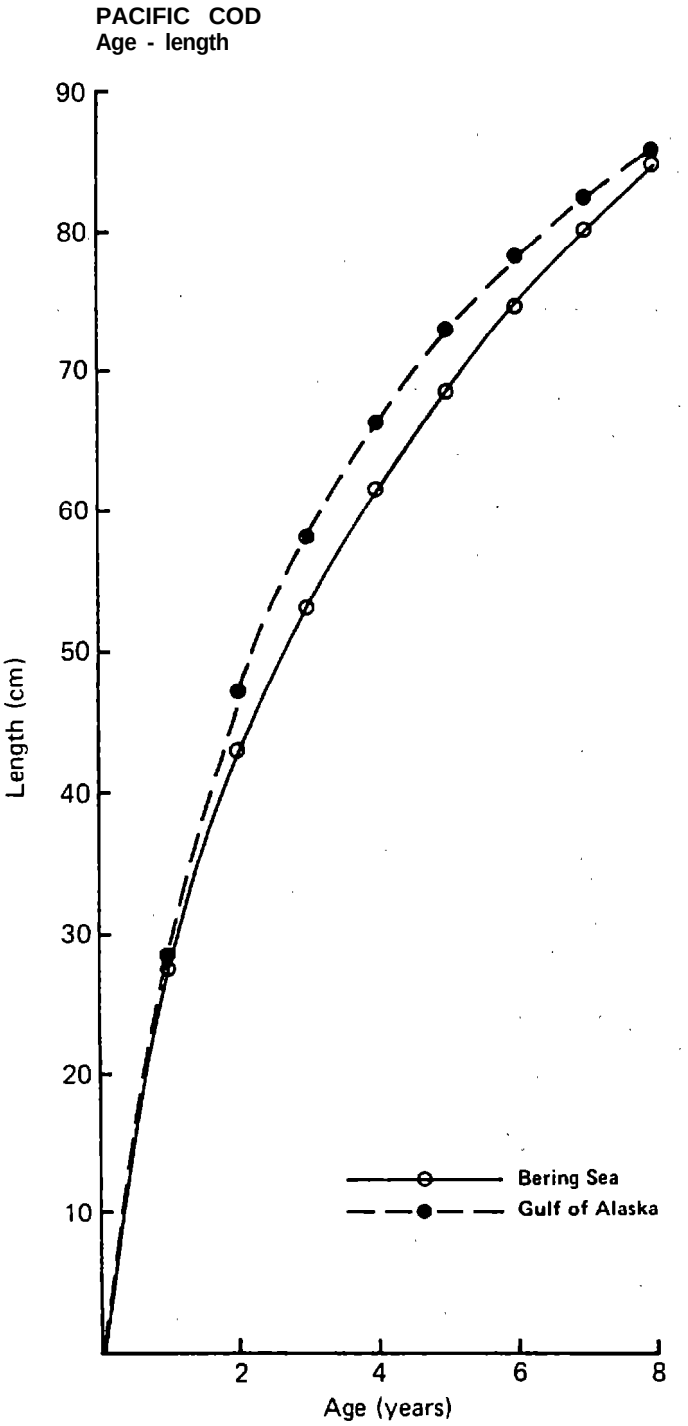
4/ Ronholt et al. 1978; Westerheim, 1977.

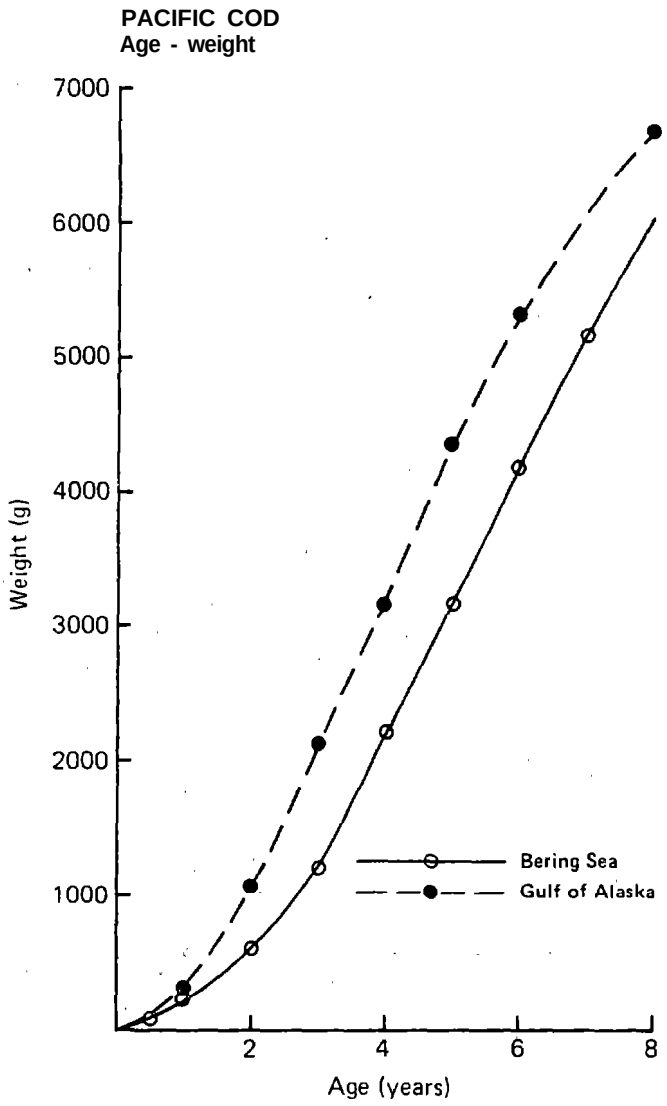
LENGTH-WEIGHT KEY

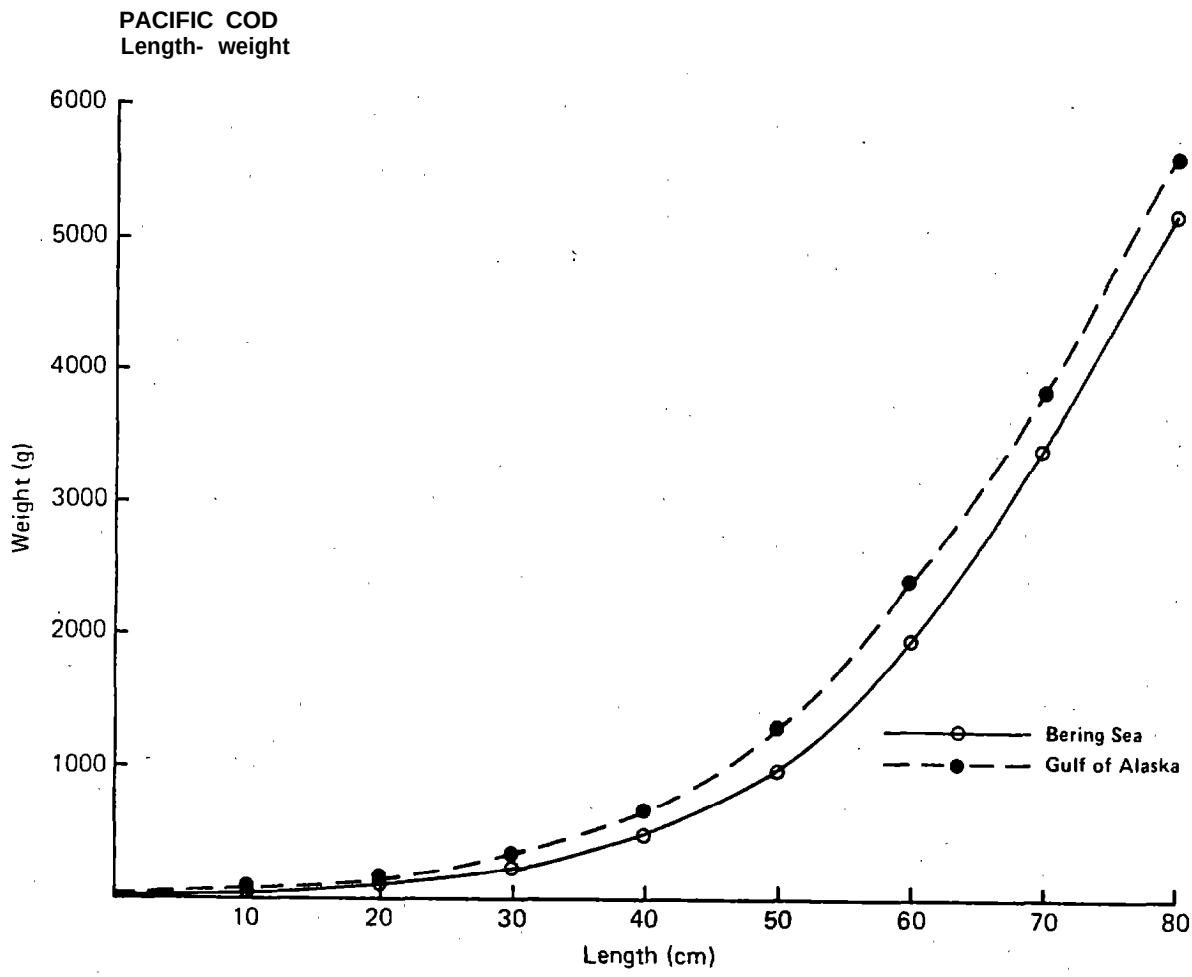
Pacific cod (Gadus macrocephalus)

(Calculated from age-length and age-weight data)

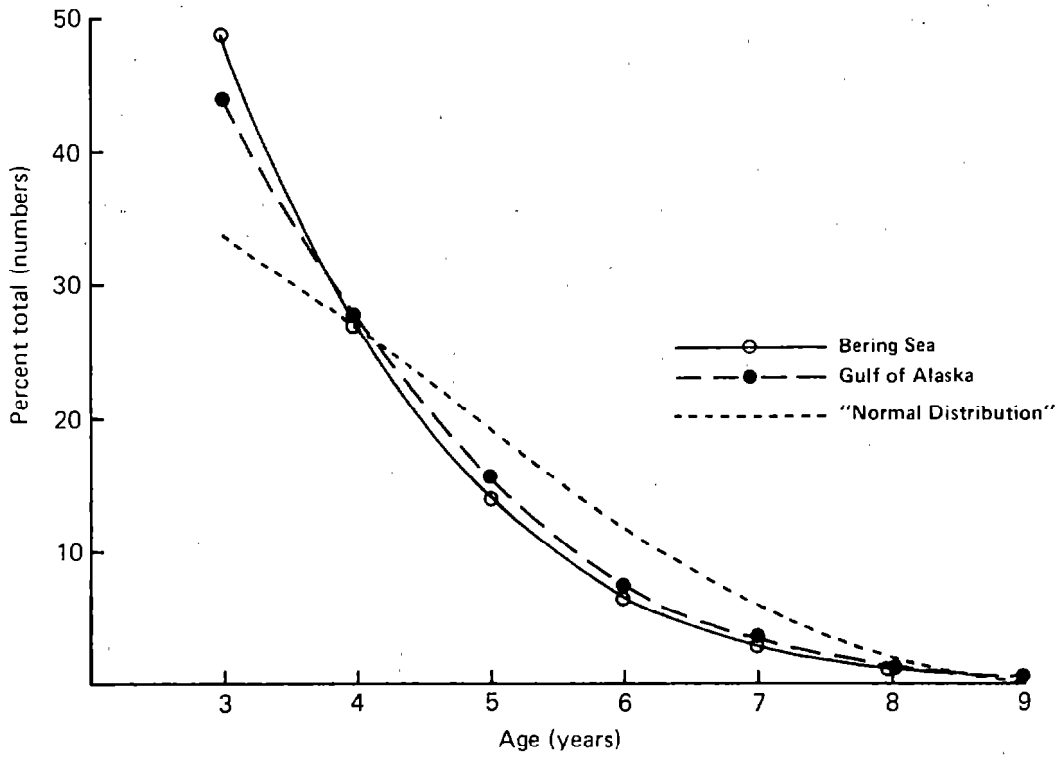
Length	Bering Sea Weight	Gulf of Alaska Weight
cm	g	g
10	50.0	55.0
20	100.0	115.0
30	225.0	325.0
40	475.0	650.0
50	955.0	1275.0
60	1945.0	2375.0
70	3400.0	3400.0
80	5150.0	5550.0


PACIFIC COD
Age - length
90
80
70
60
50
40
30
20
10
Length (cm)
2
4
6
8
Age (years)
Bering Sea
Gulf of Alaska

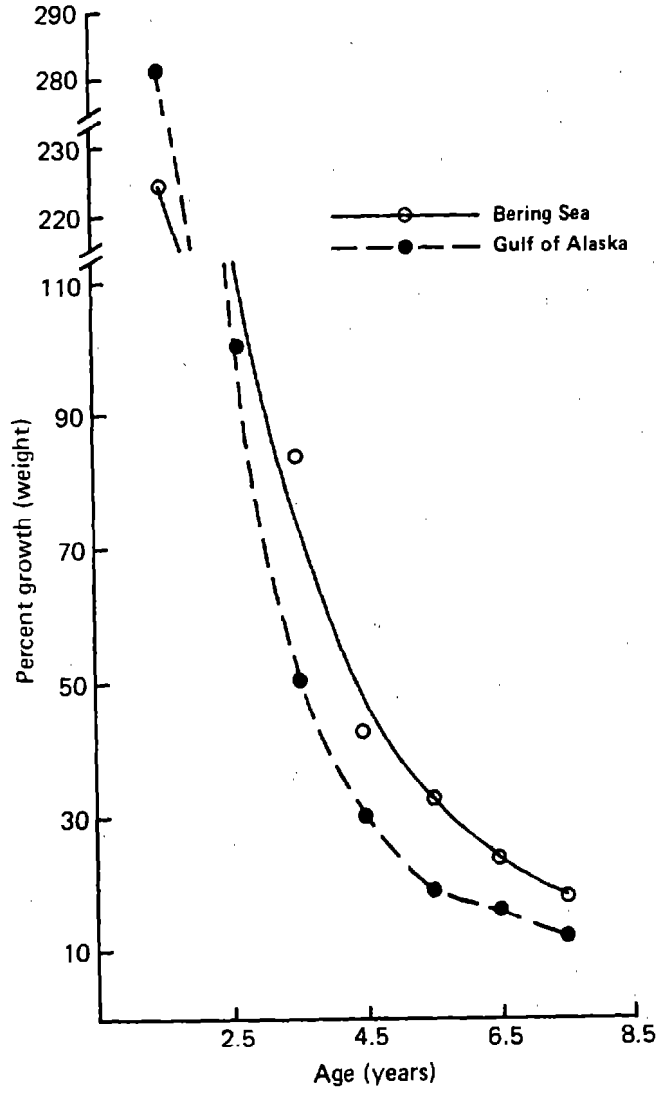

PACIFIC COD
Age - weight
7000
6000
5000
4000
3000
2000
1000
Weight (g)
2
4
6
8
Age (years)
Bering Sea
Gulf of Alaska

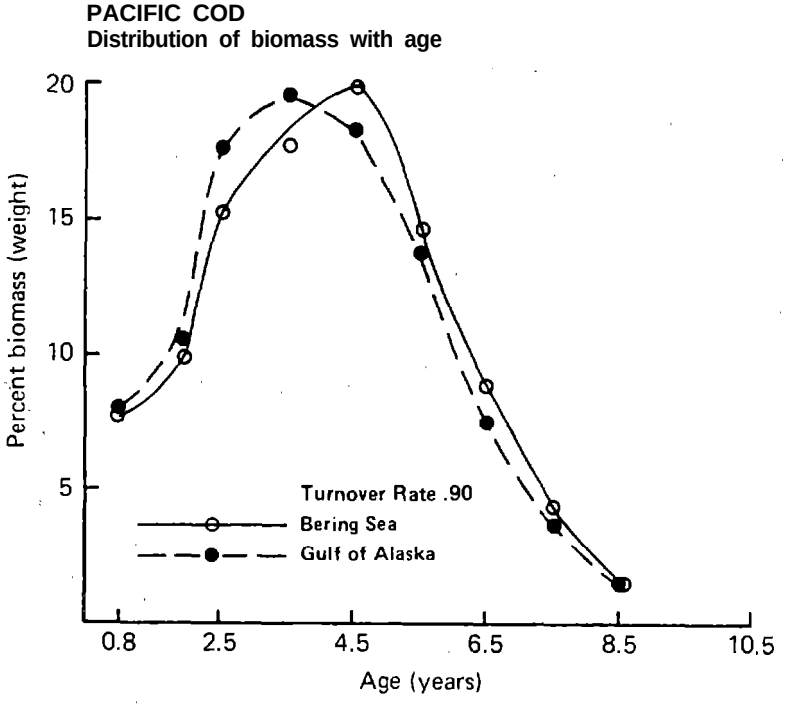

PACIFIC COD
Length- weight
6000
5000
4000
3000
2000
1000
Weight (g)
10
20
30
40
50
60
70
80
Length (cm)
Bering Sea
Gulf of Alaska

PACI F IC COD
Long term mean age composition of fully exploited year classes

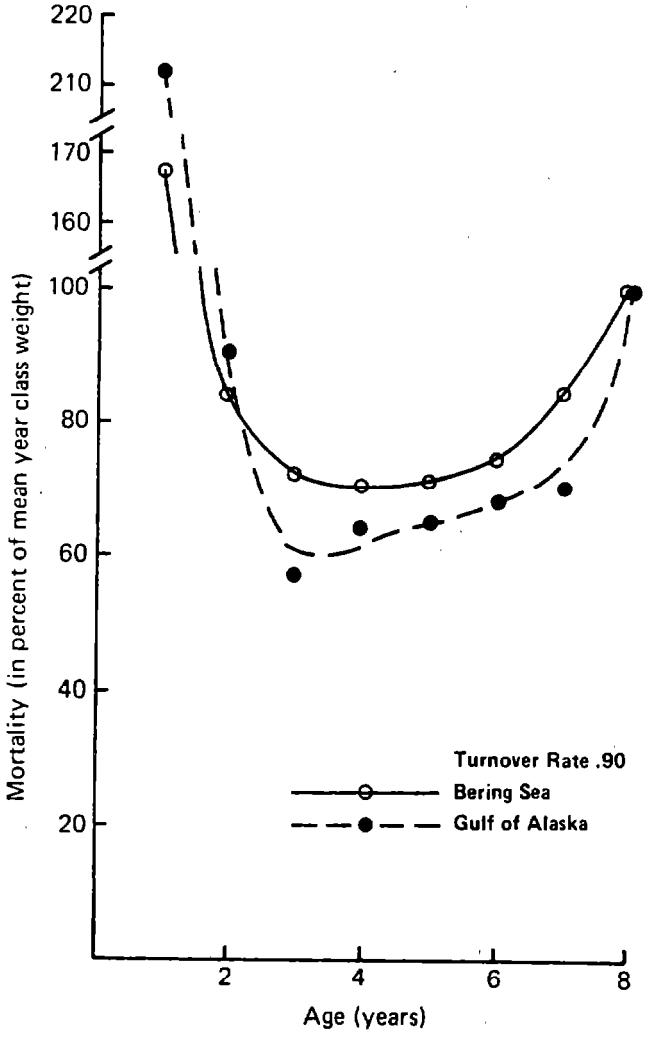


PACIFIC COD
Growth rate percent per year (weight)




PACIFIC COD
Distribution of biomass with age
Percent biomass (weight)
20
15
10
5
Turnover Rate .90
Bering Sea
Gulf of Alaska
0.8
2.5
4.5
6.5
8.5
10.5
Age (years)

PACIFIC COD
Distribution of mortality with age



5.3 SABLEFISH (Anaplopoma fimbria)

There are some uncertainties in age determination of sablefish older than six years.

It is known from tagging studies that there is considerable intermingling of the populations in the Bering Sea and in the Gulf of Alaska. It is, therefore, somewhat surprising that slight differences in length and weight at age occur between the two areas. This difference is also apparent in condition factor (length-weight relation). It might be caused by differences in availability of food for the more permanent resident fraction of the population in the two areas.

SABLEFISH (Anaplopoma fimbria)

	Gulf of, Alaska	Bering Sea
Exploitable - age (years)	(4) 5-12	(4) 6-12
length (cm)	52 to 80	60 to 80
weight (kg)	1.2 to 5.0	1.8 to 5.0
Catches - domestic (t) [1/]	20	40
foreign (t)	6100	2500
Depth - distribution (m)	50 to 1500	100 to 1200
fishing (m)	100 to 500	100 to 500
Maturity - age (years)	Male 4 Female 5	5 to 7
length (cm)	? ?	Male 55 Female 65
Spawning - season	Oct. to March	Dec. to April
area	350 to 750 m	Bowers Ridge and Aleutian Isl. regions
Fecundity	100,000 to 1,000,000	100,000 to 1,300,0C0
At a turnover rate of .65		
Exploitable biomass,%	53.9	36.1
Juvenile biomass,%	46.3	63.9
Growth rate,% per month		
Whole population	3.8	4.1
Juveniles	6.3	5.5
Adults	1.7	1.6
Deceased	5.7	5.7

Notes on food composition: Fish and crustaceans (pollock, herring, sandlance, shrimp, euphausids).

l/ Provisional estimates for 1980 (Murai et al. 1981).

AGE-LENGTH-WEIGHT KEY

Sablefish (Anoplopoma fimbria)

Age	Bering Sea		Gulf of Alaska	
	Length[1/] cm	Weight[2/] g	Length[3/] cm	Weight[4/] g
1	21.0	125.0	22.5	125.0
2	35.0	375.0	37.2	475.0
3	45.0	675.0	47.5	875.0
4	52.0	1050.0	54.0	1375.0
5	56.7	1450.0	59.3	1950.0
6	61.0	1900.0	63.8	2600.0
7	64.5	2355.0	67.7	3250.0
8	68.0	2875.0	71.5	3925.0
9	71.0	3425.0	75.5	4665.0
10	74.0	3975.0	79.0	5375.0
11	77.0	4525.0		
12	80.0	5050.0		

l/ Sasaki 1978; Sasaki 1981; Low et al. 1976; Pereyra et al. 1976.

2/ Low et al. 1978; Pereyra et al. 1976.

3/ Sasaki 1978, 1981; Kennedy and Pletcher 1968; Webb and Lockner 1973.

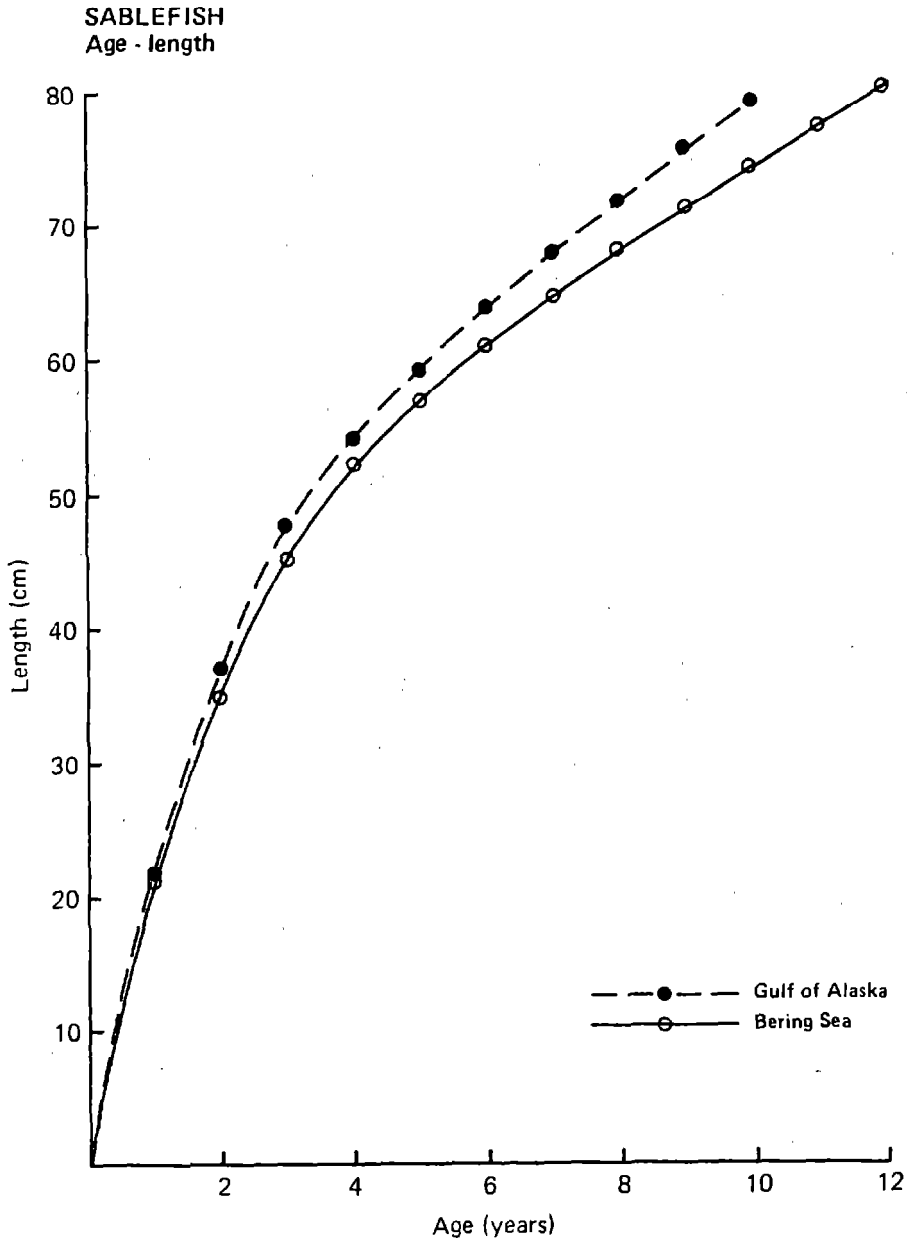
4/ Groundfish cruises 1978-79, 80-81.

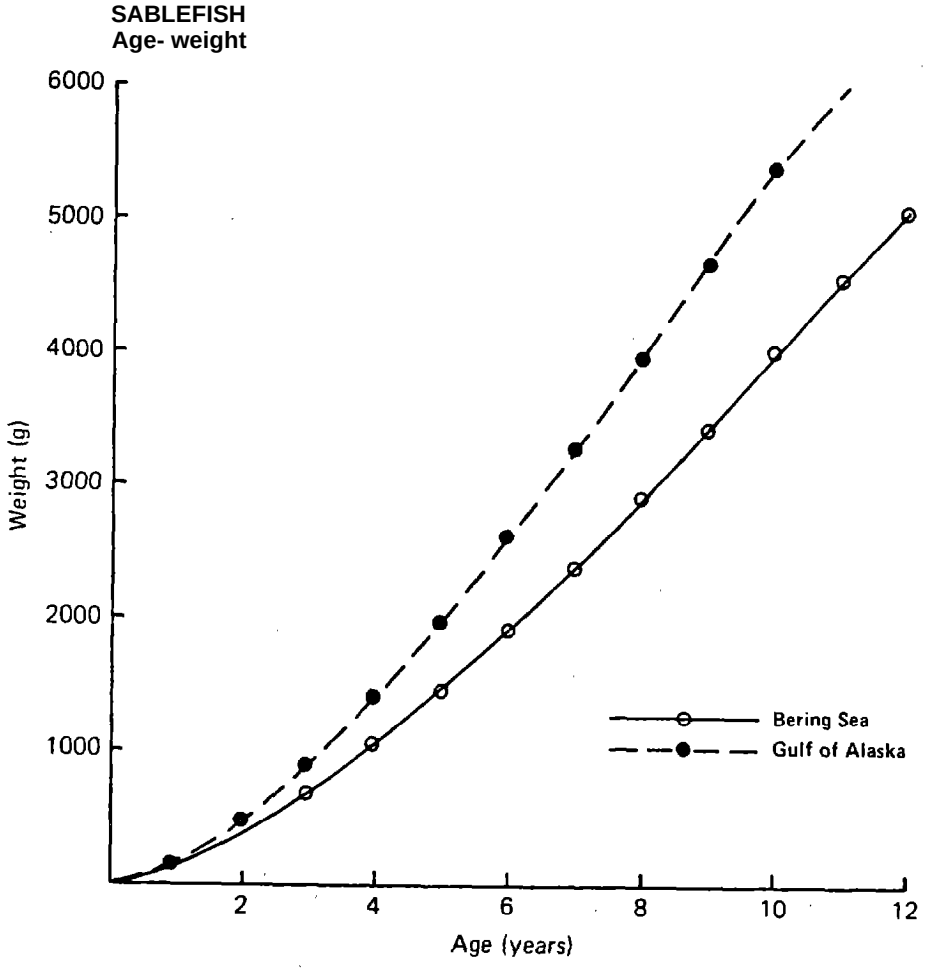
LENGTH-WEIGHT-KEY

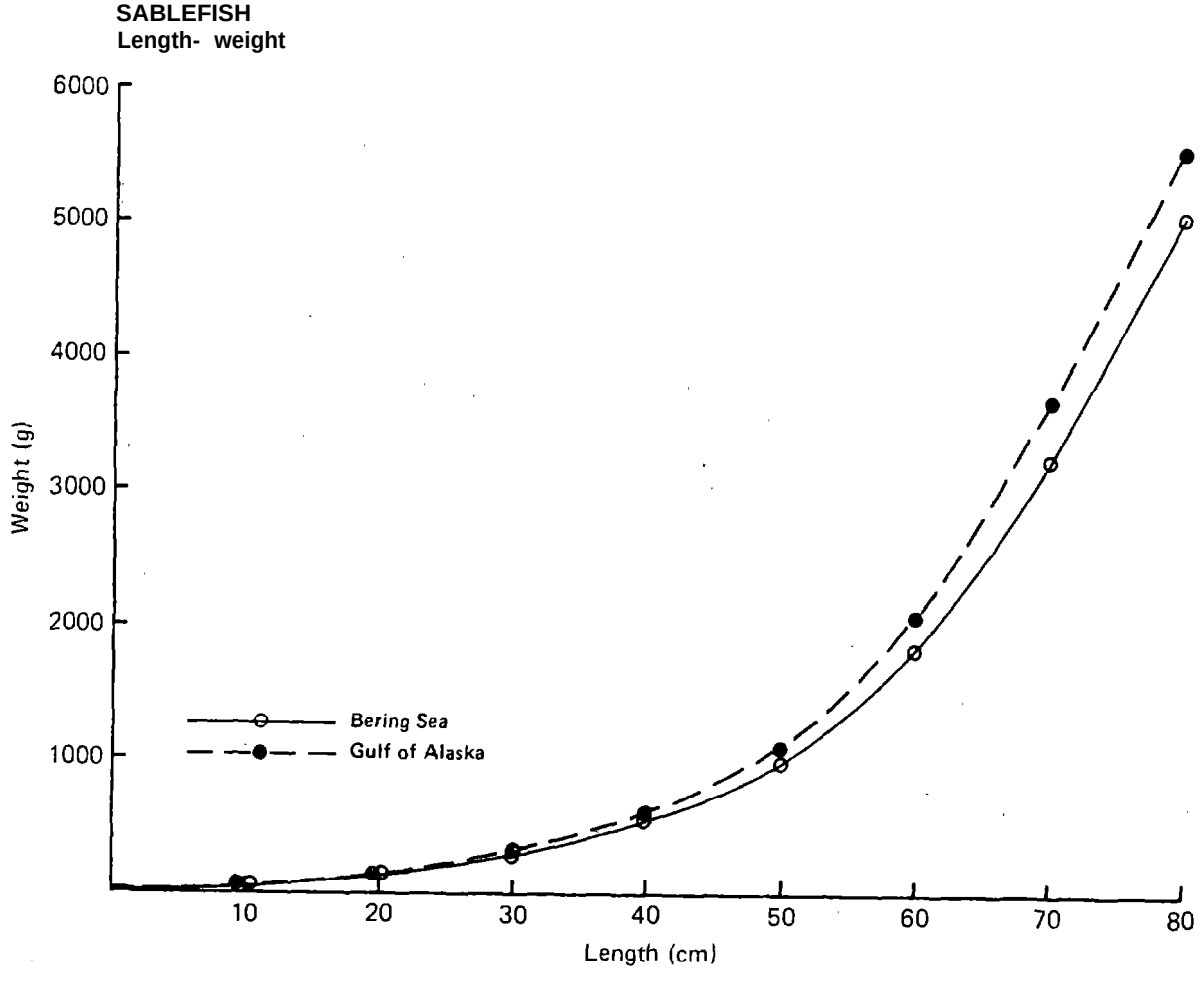
Sablefish (Anoplopoma fimbria)

(Calculated from age-length and age-weight data)

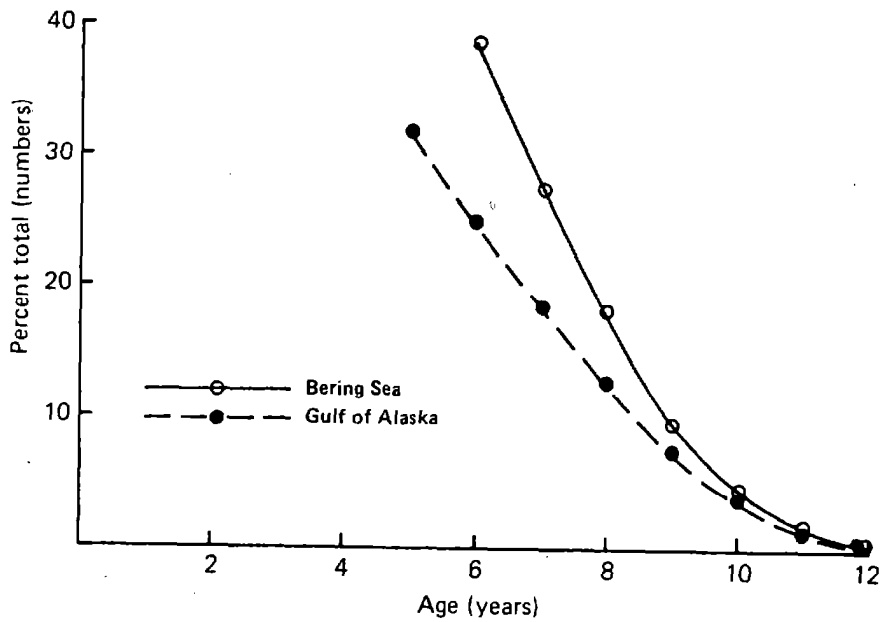
Length cm	Bering Sea Weight g	Gulf of Alaska Weight g
10	35.0	35.0
20	120.0	120.0
30	275.0	300.0
40	502.5	575.0
50	925.0	1050.0
60	1800.0	2050.0
70	3225.0	3650.0
80	5025.0	5505.0

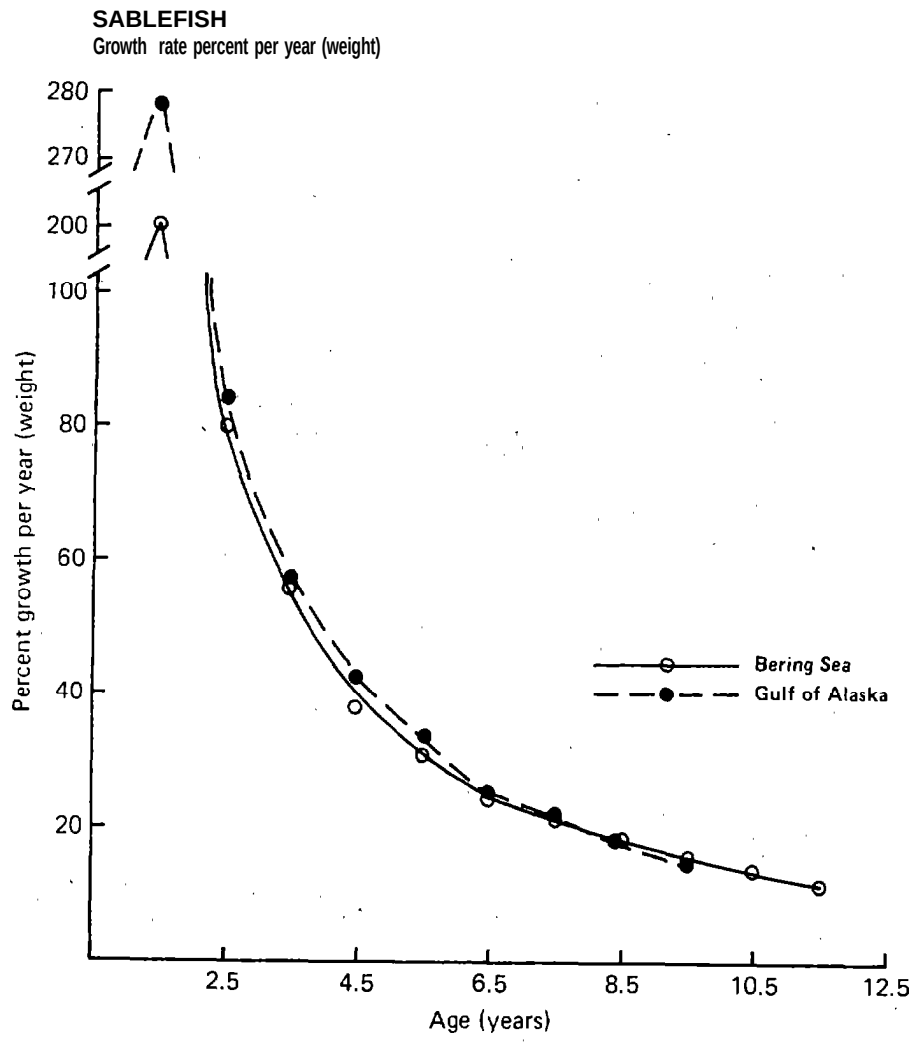

SABLEFISH
Age - length
Length (cm)
80
70
60
50
40
30
20
10
2
4
6
8
10
12
Age (years)
Gulf of Alaska
Bering Sea


SABLEFISH
Age- weight
6000
5000
4000
3000
2000
1000
Weight (g)
2
4
6
8
10
12
Age (years)
Bering Sea
Gulf of Alaska

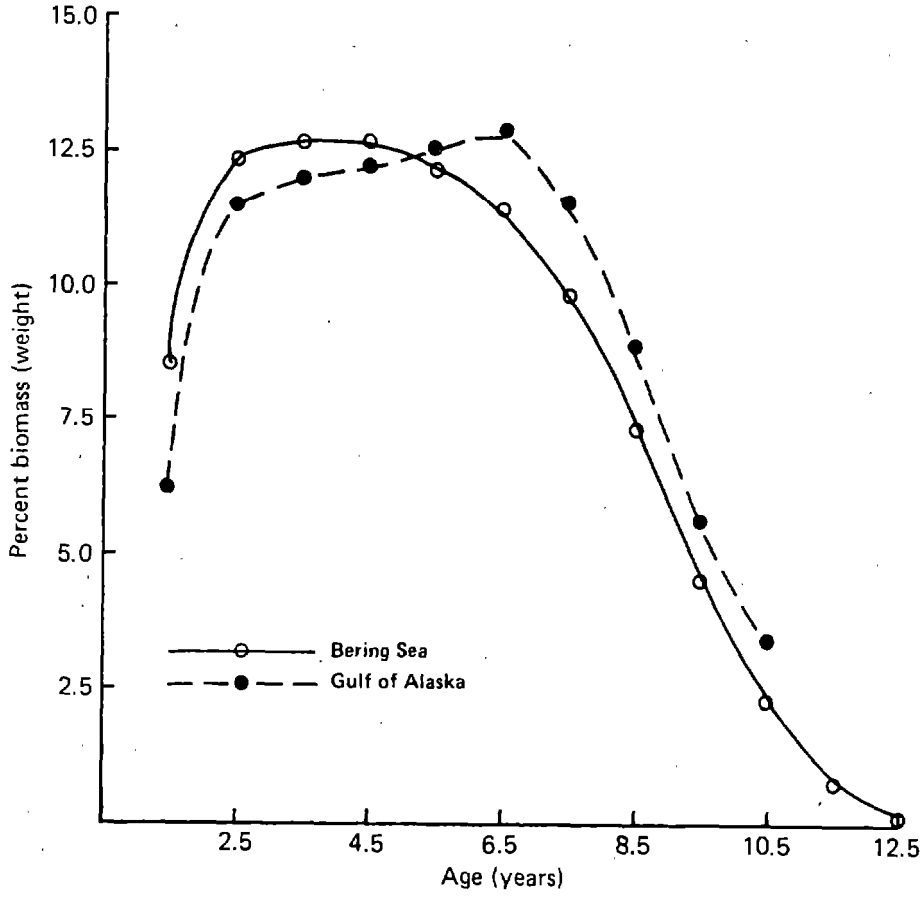

SABLEFISH
Length- weight
6000
5000
4000
3000
2000
1000
Weight (g)
Bering Sea
Gulf of Alaska
10
20
30
40
50
60
70
80
Length (cm)

SABLEFISH
Long term mean age composition of fully exploited year classes

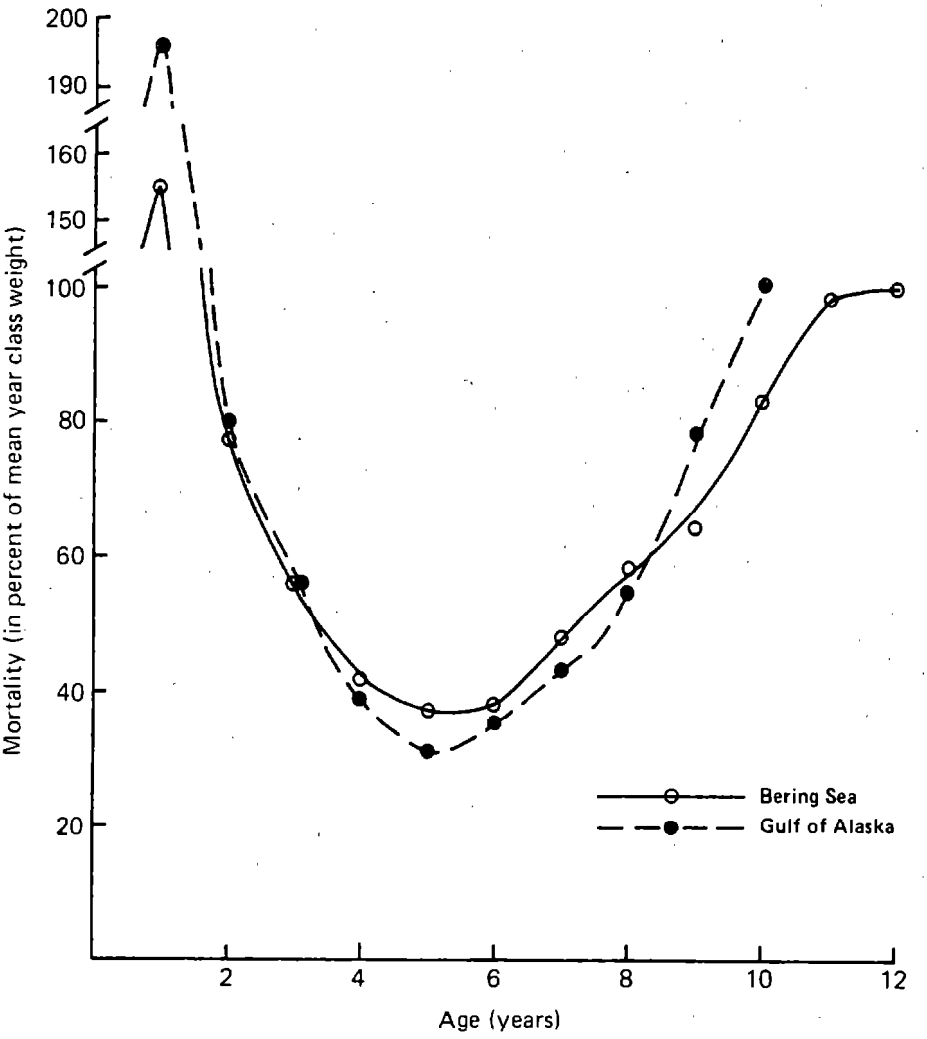



SABLEFISH
Growth rate percent per year (weight)
280
270
200
100
80
60
40
20
Percent growth per year (weight)
2.5
4.5
6.5
8.5
10.5
12.5
Age (years)
Bering Sea
Gulf of Alaska

SABLEFISH
Distribution of biomass with age



SABLEFISH
Distribution of mortality with age



5.4 YELLOWFIN SOLE (Limanda aspera)

The biometric data on yellowfin sole is meager for the Gulf of Alaska. The data used in this summary for Gulf of Alaska originates from Auke Bay. The comparison of some older age-length data with the more recent data from the Bering Sea indicates that the growth rate for yellowfin sole might have changed.

Yellowfin sole grows considerably faster in the Gulf of Alaska (temperature effect), but has a somewhat lower condition factor than the fish from the Bering Sea. Due to its faster growth in the Gulf of Alaska, the species comes under the fishery at an earlier age than in the Bering Sea. Due to the faster growth and earlier maturation of the yellowfin sole in the Gulf of Alaska, there are considerably fewer older fish in the latter area than in the Bering Sea--the age composition after the maturation being controlled by spawning stress mortality;

Data in the literature about the size and age of maturity are controversial.

YELLOWFIN SOLE (*Limanda aspera*)

	SE Alaska	Bering Sea
Exploitable-age (years)	4-13	6-15
length (cm)	20-30	20-30
weight (g)	100-500	100-375
Catches-domestic (t) [1/]	Minor fishery	9,600
foreign (t) [1/]	10 ?	80,000
Depth-distribution (m)	10-200	10-500
fishing (m)	<l00	<l00 in summer 100-300 in winter
Maturity-age (years)	3 to 6	4 to 8
length (cm)	17-25	50% female at 20-25 50% male at 16-18
Spawning-season	May-June	June to August
area	SE Alaska bays, Kodiak	Bristol Bay and north on the shelf to Nunivak Isl.
Fecundity	Average 800,000	1,300,000 to 3,300,000
At a turnover rate of .65		
Exploitable biomass,%	73.8	45.4
Juvenile biomass)%	26.2	54.6
Growth rate, % per month		
Whole population	3.3	4.0
Juveniles	6.3	6.9
Adults	2.1	1.6
Deceased	4.9	5.9

Notes on food composition: Most important food items- polychaetes, crustaceans, bivalve mollusks, echiuroids, ascidians.

1/ Provisional estimates for 1980 (Murai et al. 1981).

AGE-LENGTH-WEIGHT KEY

Yellowfin sole (Limanda aspera)

Age	Bering Sea		Gulf of Alaska	
	Length[1/] cm	Weight[2/] g	Length[3/] cm	Weight[4/] g
1	5.0	6.3	8.3	7.0
2	9.0	17.5	14.8	25.5
3	12.5	31.3	19.5	60.0
4	15.8	51.2	22.7	100.5
5	18.5	75.0	24.8	142.5
6	20.8	98.8	26.2	195.0
7	22.8	126.3	27.7	245.0
8	24.3	158.8	28.8	290.0
9	25.7	186.3	29.7	335.0
10	26.8	213.0	30.8	387.5
11	27.7	242.5	31.5	431.5
12	28.5	273.0	32.2	470.0
13	29.0	306.2	32.6	505.0
14	29.5	340.7		
15	30.0	375.0		

1/ Bakkala et al. 1976; Weber & Shippen 1974; Maeda 1969; Bakkala & Smith 1978.

2/ Bakkala 1979 (79-20); Bakkala et al. 1976; Observer program 1974-79, Weber & Shippen 1975.

3/ Auke Bay data (1,576 fish); M/F Cruise 783.

4/ Auke Bay data.

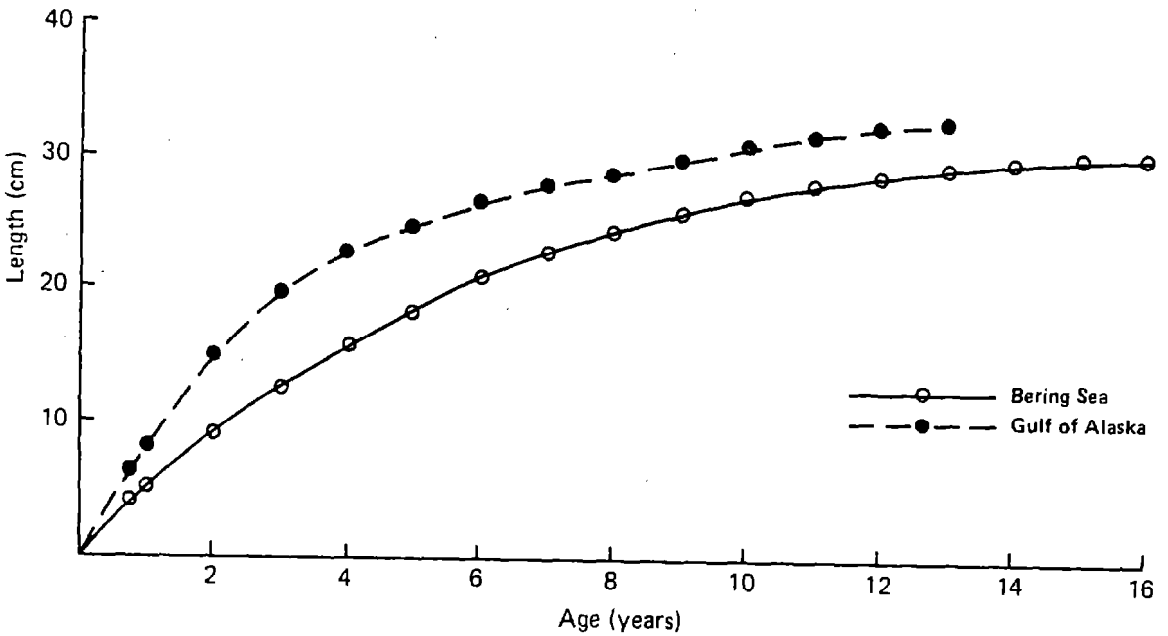
LENGTH-WEIGHT KEY

Yellowfin sole (Limanda aspera)

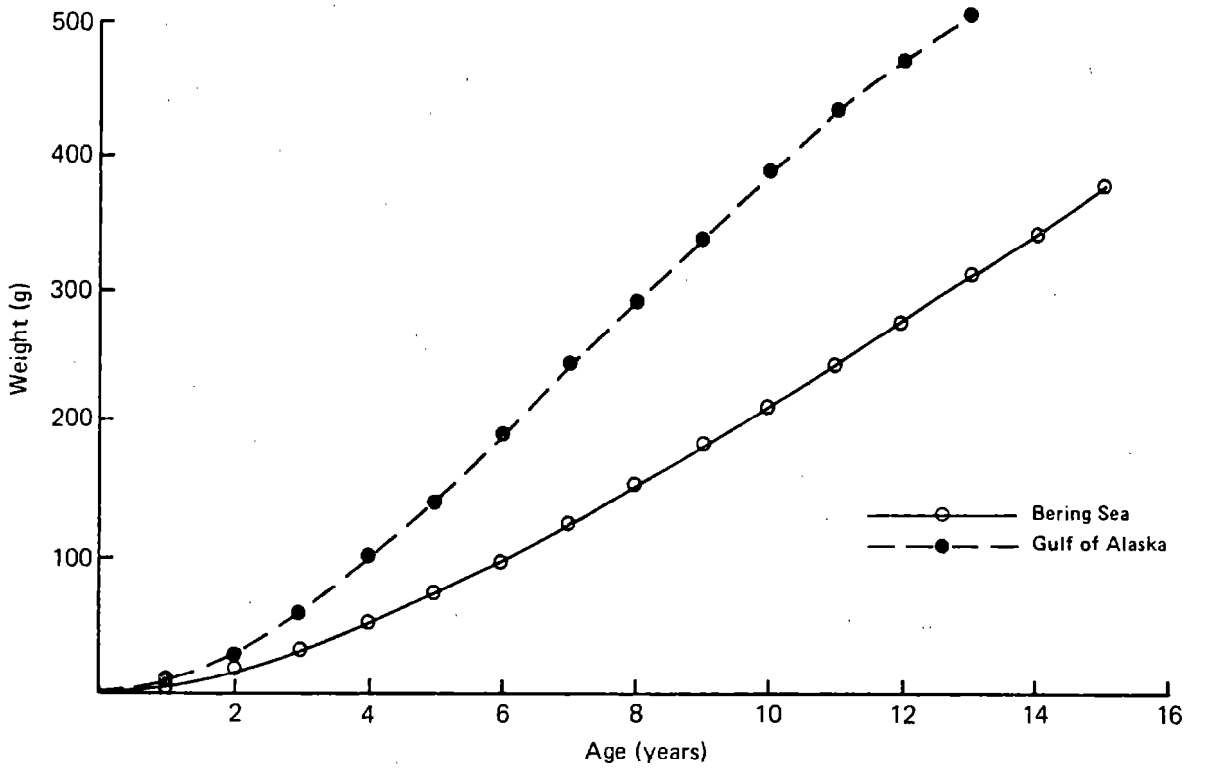
(Calculated from age-length and age-weight data)

Length cm	Bering Sea Weight g	Gulf of Alaska Weight g
5	6.3	6.5
10	20.2	15.8
15	45.6	28.8
20	86.5	67.5
25	167.5	150.0
30	375.0	345.0

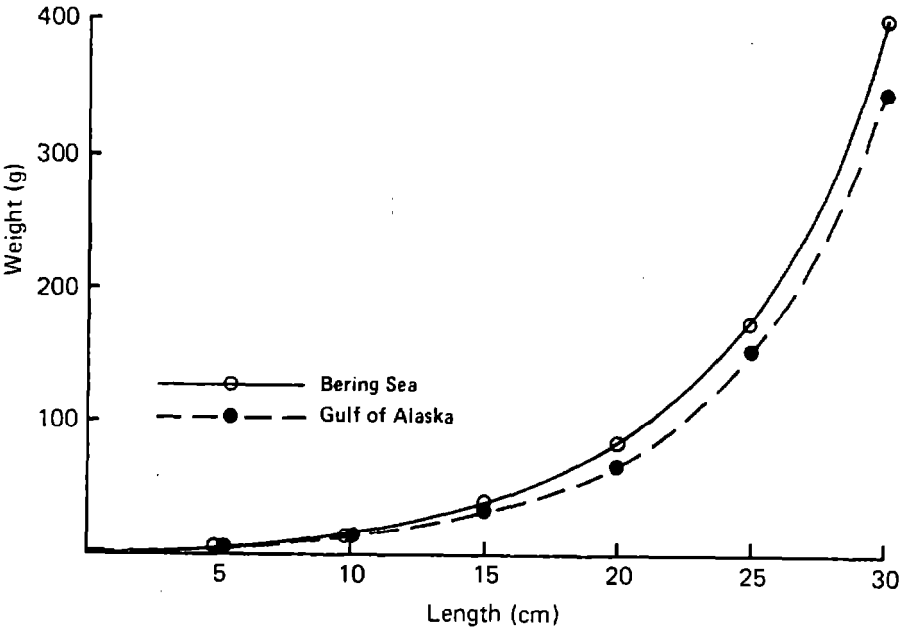
YELLOWFIN SOLE
Age-length



YELLOWFIN SOLE
Age- weight

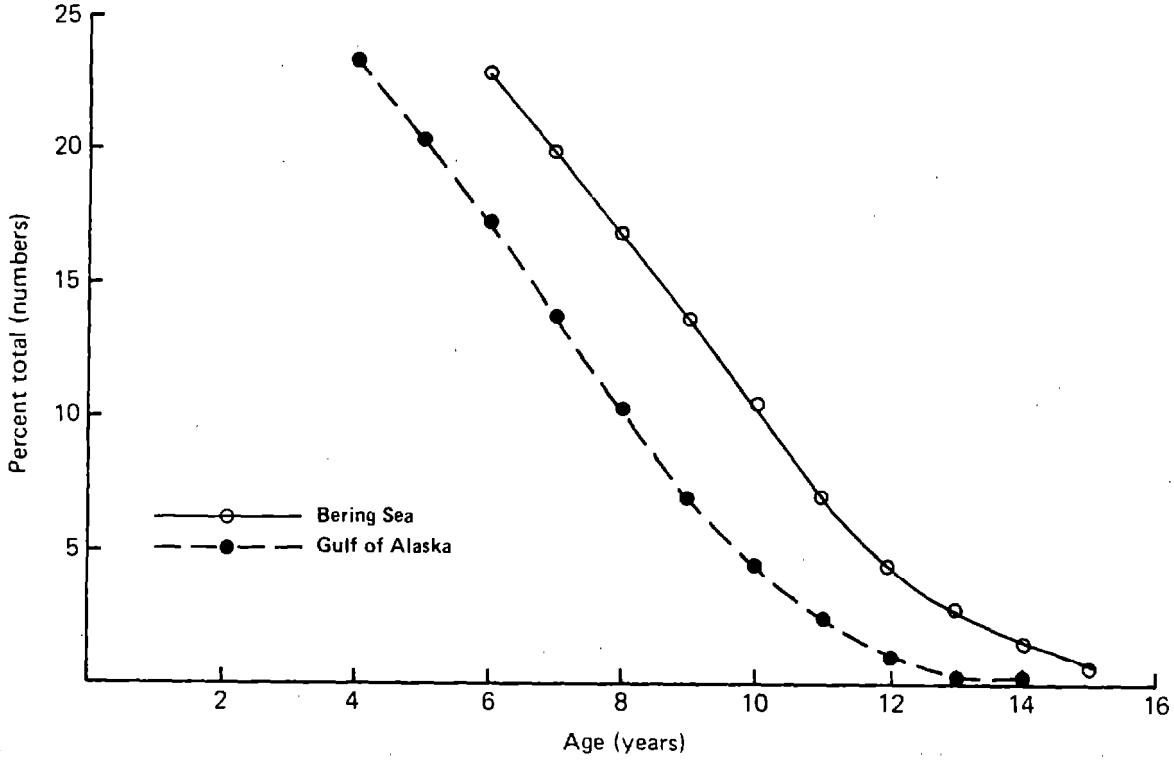


YELLOWFIN SOLE
Length-weight

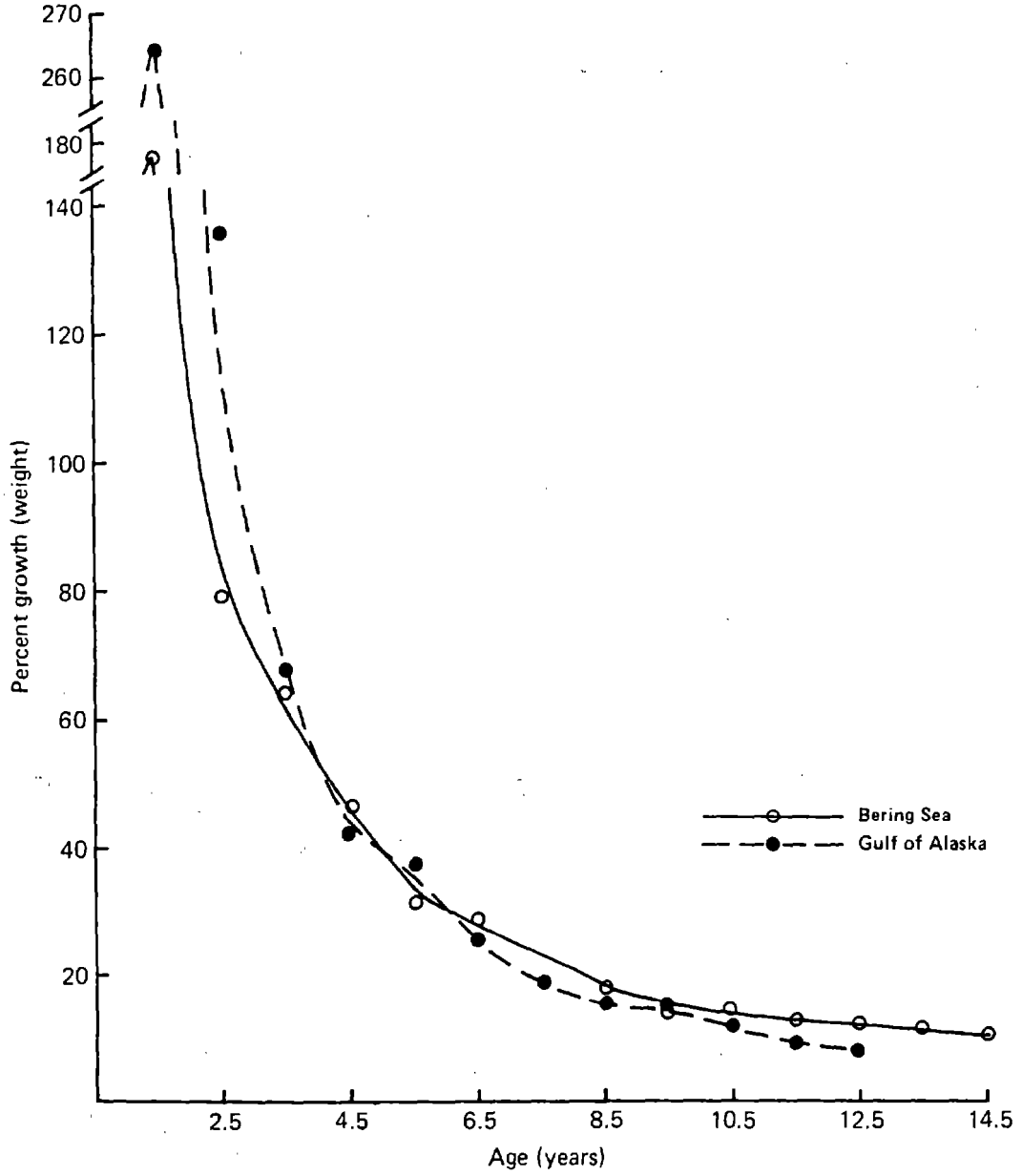


YELLOWFIN SOLE

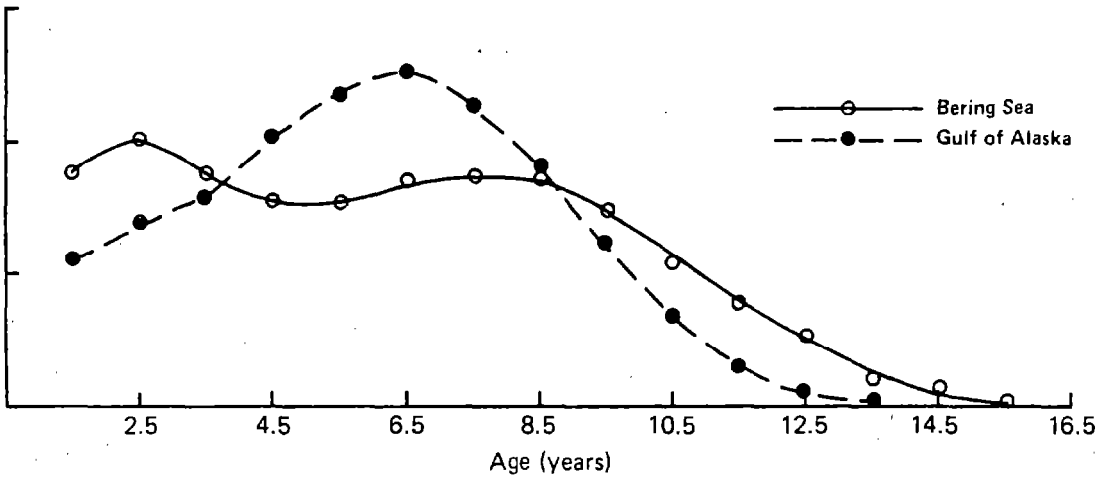
Long term mean age composition of fully exploited year classes



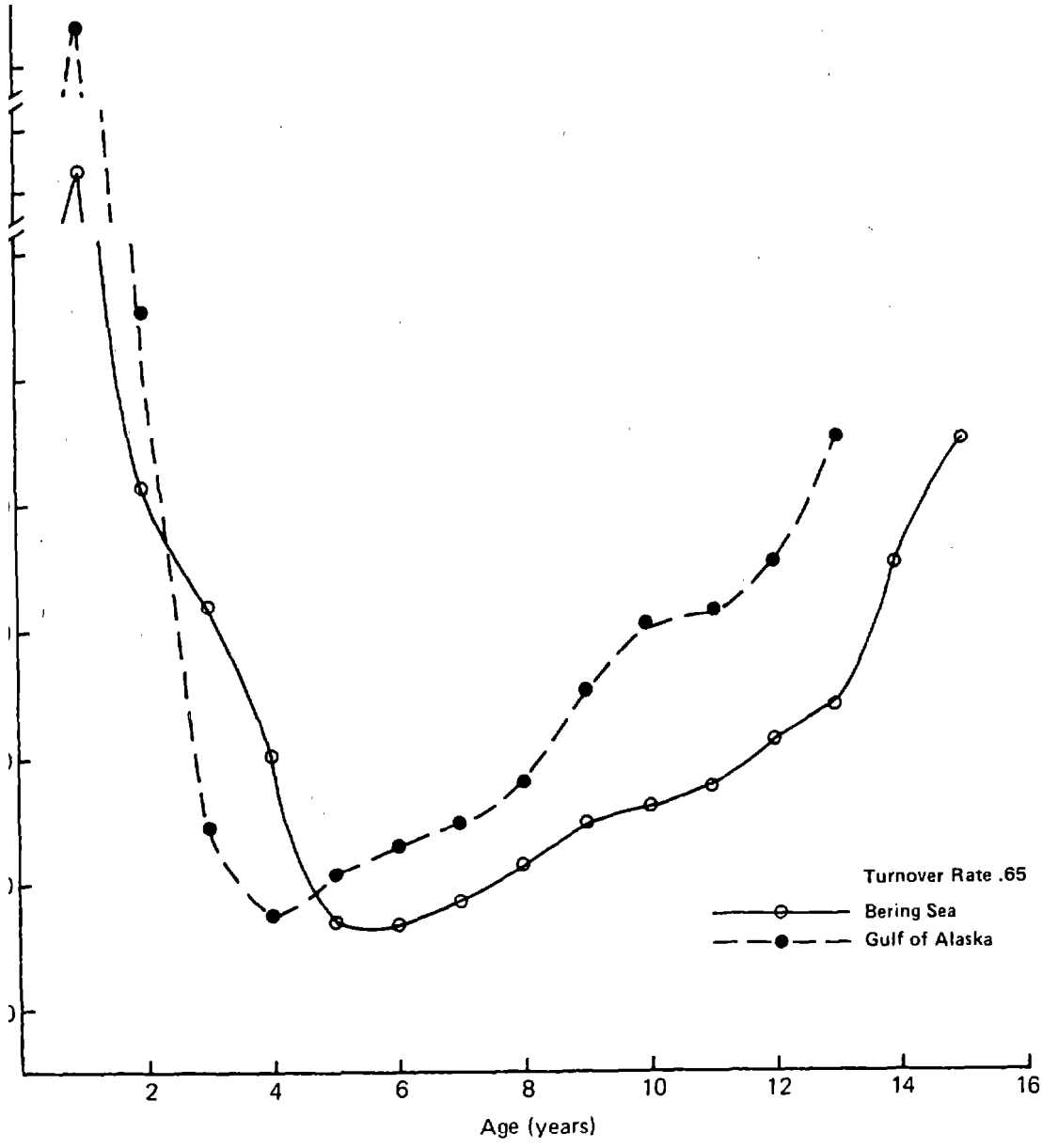
YELLOWFIN SOLE
Growth rate percent per year (weight)



YELLOWFIN SOLE
Distribution of biomass with age



YELLOWFIN SOLE
Distribution of mortality with age



5.5 GREENLAND TURBOT (Reinhardtius hippoglossoides)

Greenland turbot (or Greenland halibut) occurs both in the Bering Sea and in the Gulf of Alaska. However, no biometric data are available from the Gulf of Alaska.

As Greenland turbot is a very minor constituent of U.S. catch and, as concentrations of these species occur in deeper water (ZOO to 700 m) out of routine resource survey range, only a minimal amount of biometric data on this species exists.

The long-term mean age composition of fully exploited year classes indicates that the first fully exploited age (5 years) is probably over-represented because younger fish occur in shallower water and are easily available to resource surveys. The decrease of the frequency of year classes between 6 and 16 years indicates that the species is but slightly exploited.

The data on maturity of this species is meager indeed. Judging from the distribution of mortality with age, it seems that 50% maturity occurs at age 10 to 11 whereafter the spawning stress mortality follows a normal path.

GREENLAND TURBOT (Reinhardtius hippoglossoides)

	Gulf of Alaska	Bering Sea
Exploitable-age (years)	No data available	(4) 5 to 16
-length (cm)		(35) 40 to 75
-weight (cm)	for Gulf of Alaska	600 to 4000
Catches-domestic (t)		Minor (5)
foreign (t)		30,000
Depth- distribution (m)		60 to 900
fishing (m)		80 to 600
Maturity-age (years)		13-14
length (cm)		50 to 70
Fecundity		(15,000 to 215,000)
At a turnover rate of .65		
Exploitable biomass,%		61.3
Juvenile biomass,%		38.7
Growth rate, % per month		
Whole population		3.2
Juveniles		5.7
Adult		1.6
Deceased		5.0

Main food items: fish, squids, shrimps, amphipods.

AGE-LENGTH-WEIGHT KEY

Greenland turbot (Reinhardtius hippoglossoides)

Age	Bering Sea Length cm [1/]	Bering Sea Weight g	
0.8		36.0	No data available for Gulf of Alaska
1	11.8	48.0	
2	23.0	152.0	
3	31.4	340.0	
4	39.5	596.0	
5	44.5	904.0	
6	50.5	1260.0	
7	54.3	1620.0	
8	57.9	1980.0	
9	61.5	2320.0	
10	64.4	2620.0	
11	67.0	2920.0	
12	69.8	3180.0	
13	72.0	3440.0	
14	75.5	3632.0	
15	76.7	3800.0	
16	78.0	3920.0	

1/ Pereyra et al. 1976; Bakkala and Smith 1978; Mikava, Masao 1963.

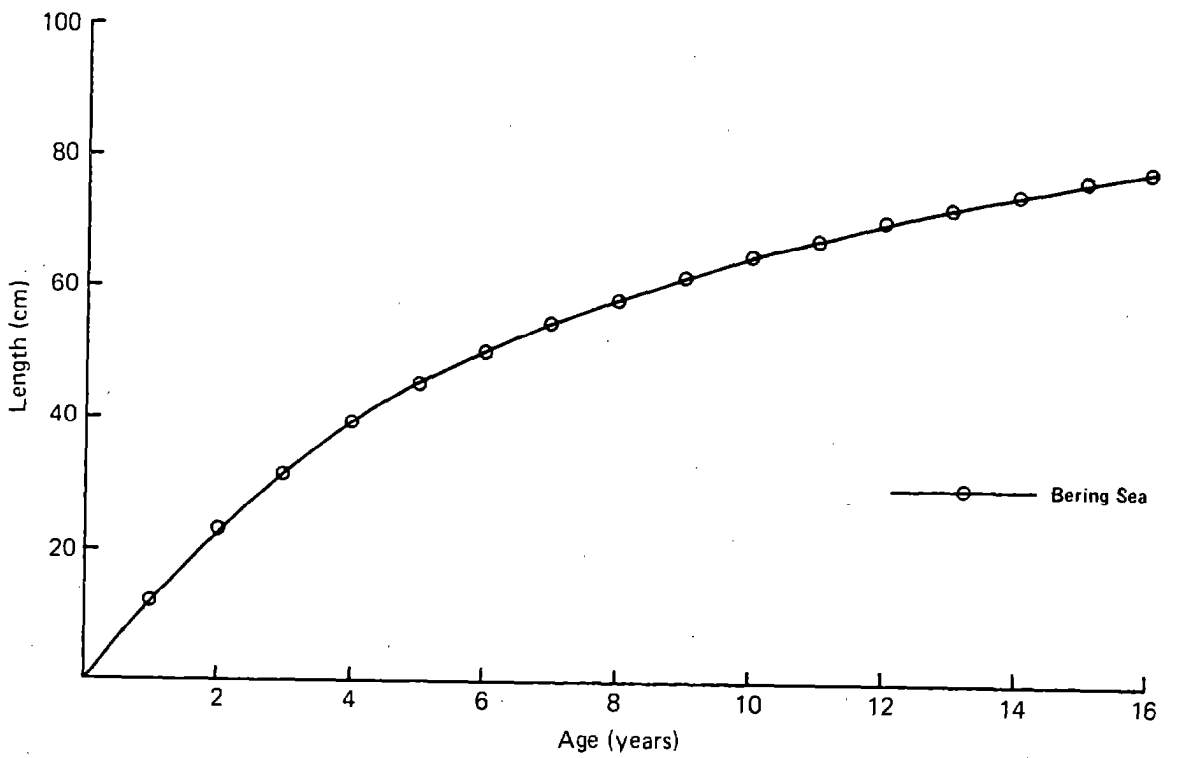
LENGTH-WEIGHT KEY

Greenland turbot (Reinhardtius hippoglossoides)

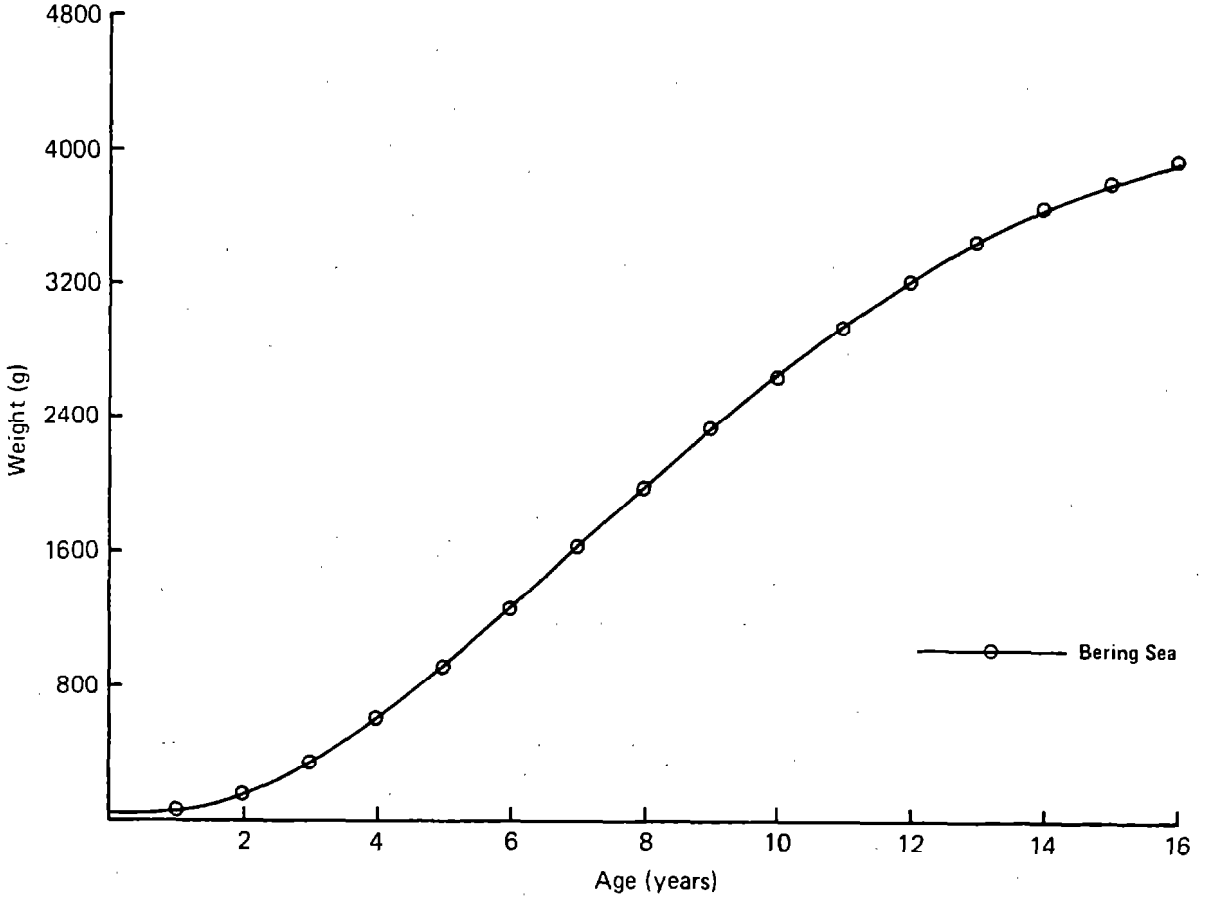
(Calculated from age-length and age-weight data)

Length cm	Bering Sea Weight g	
10	44.0	No data available for Gulf of Alaska
20	120.0	
30	296.0	
40	636.0	
50	1240.0	
60	2136.0	
70	3200.0	
80	4087.0	

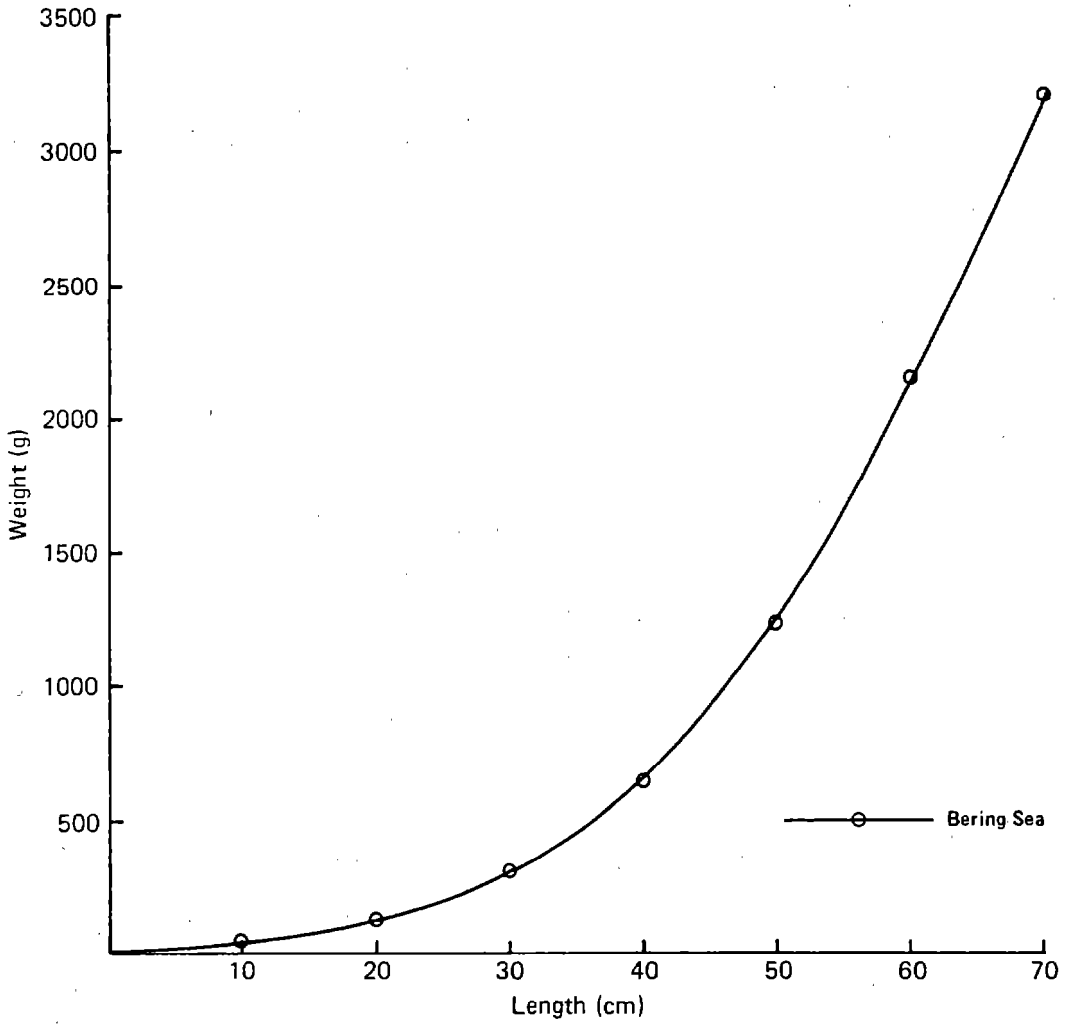
GREENLAND TURBOT
Age-length



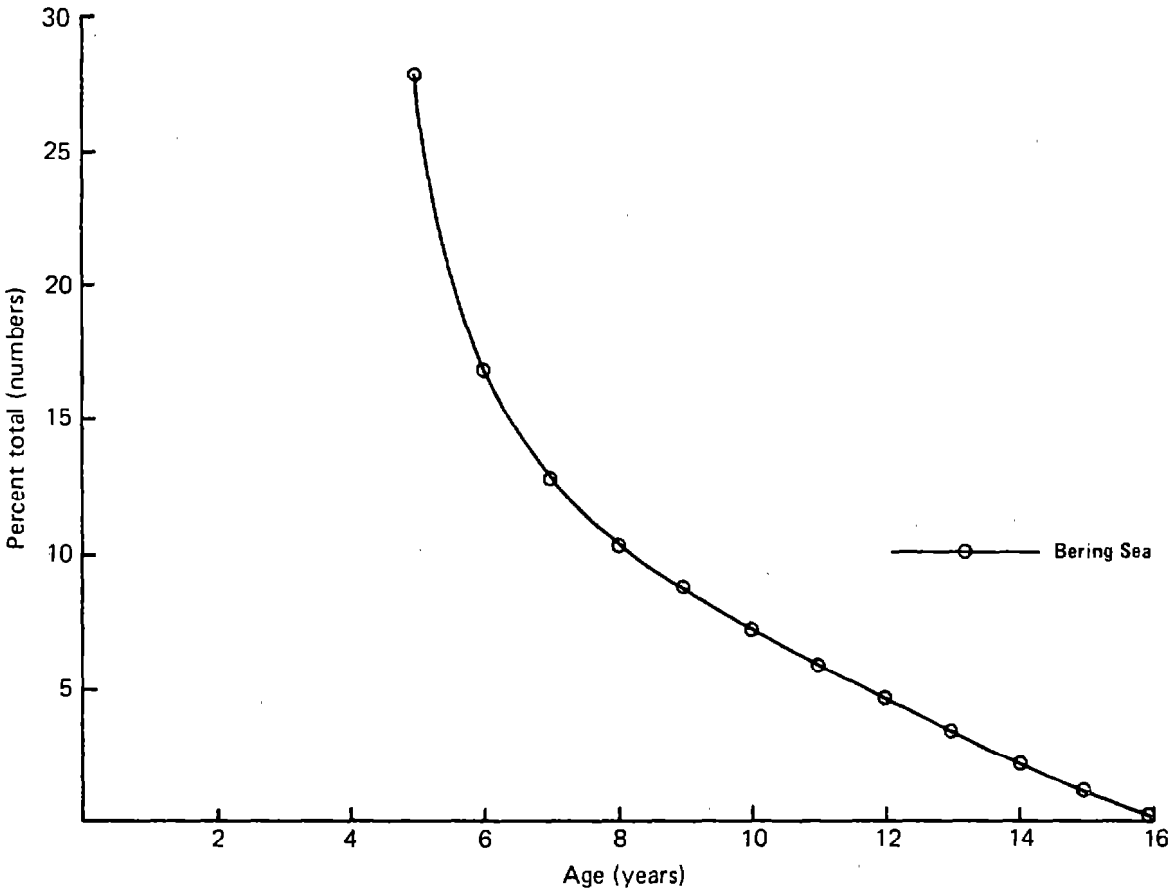
GREENLAND TURBOT
Age-weight



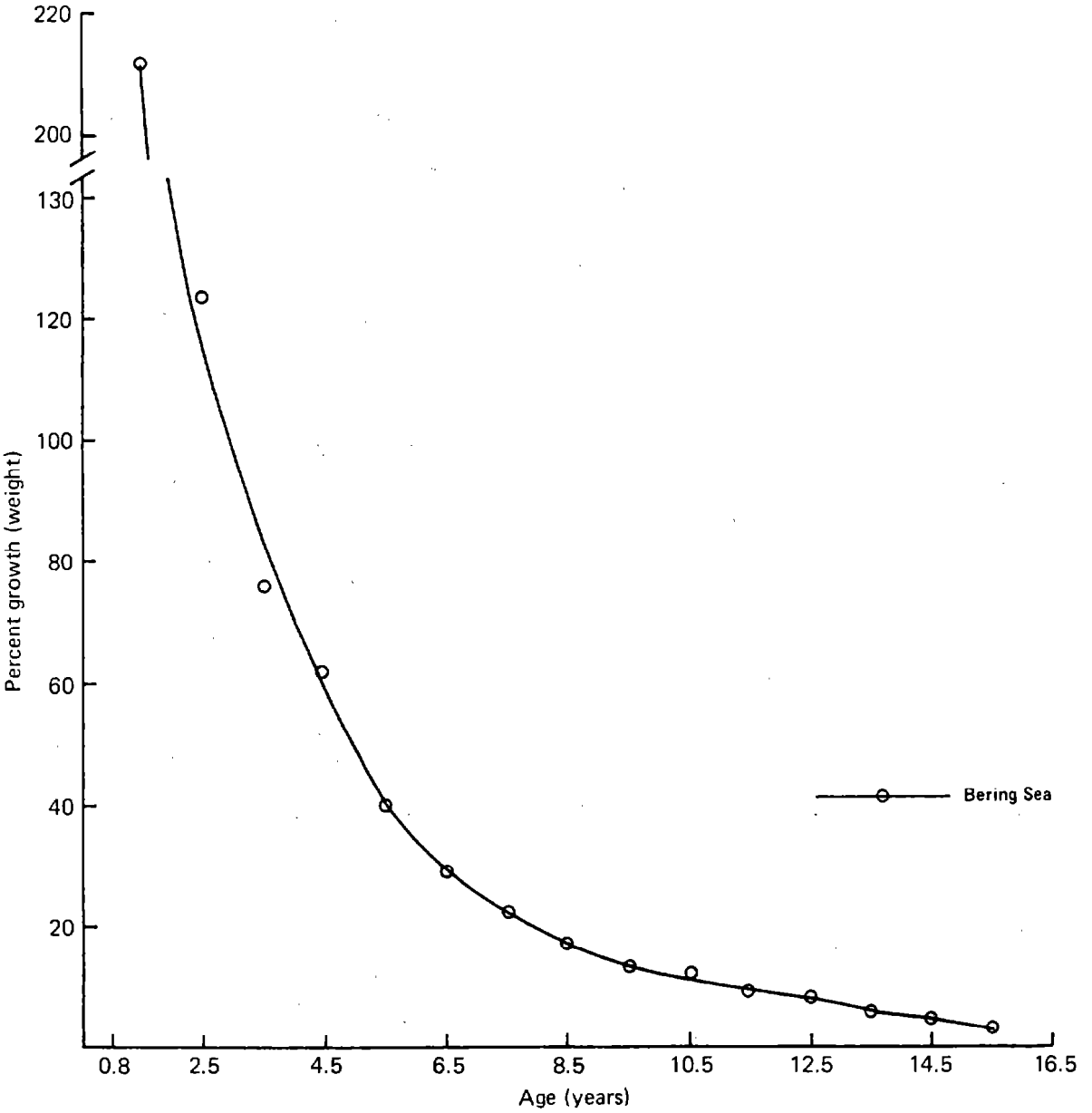
GREENLAND TURBOT
Length- weight



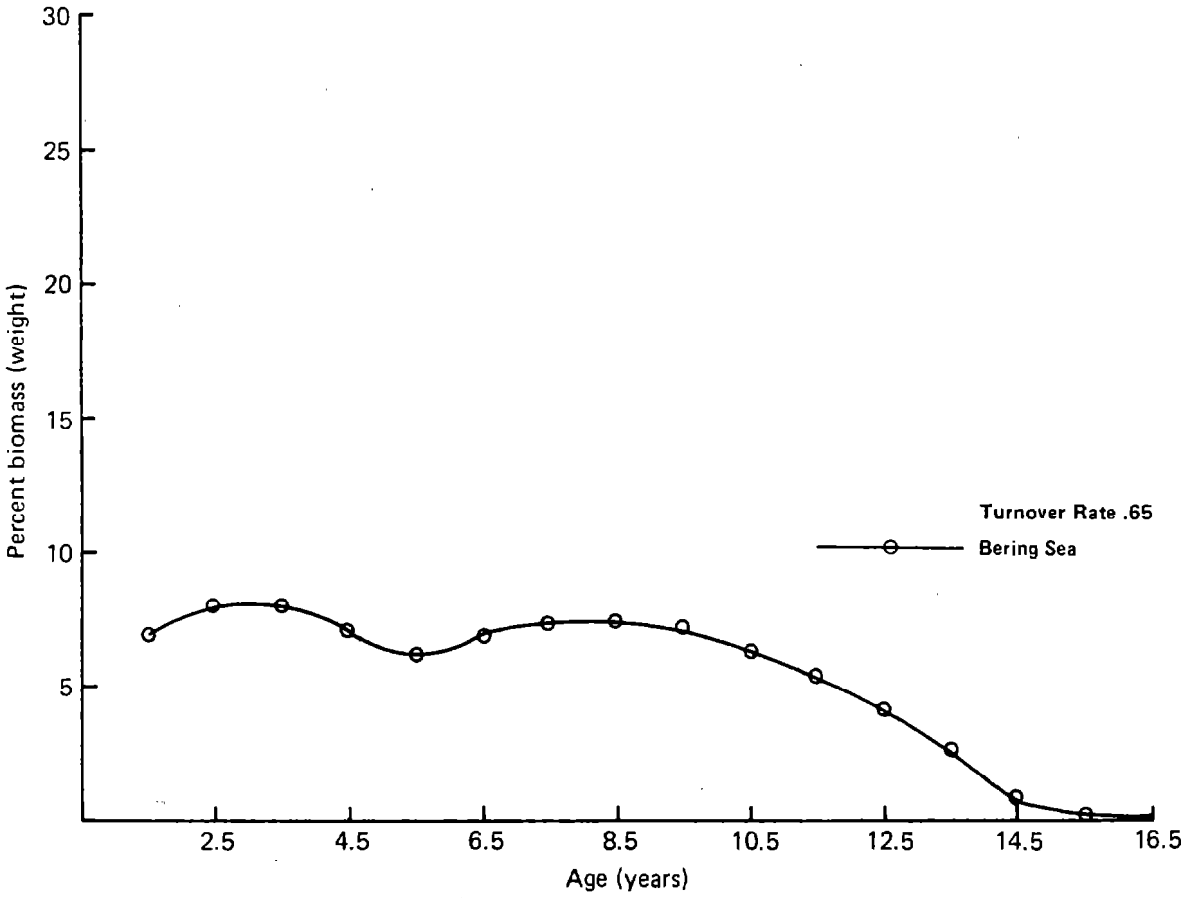
GREENLAND TURBOT
Long term mean age composition of fully exploited year classes



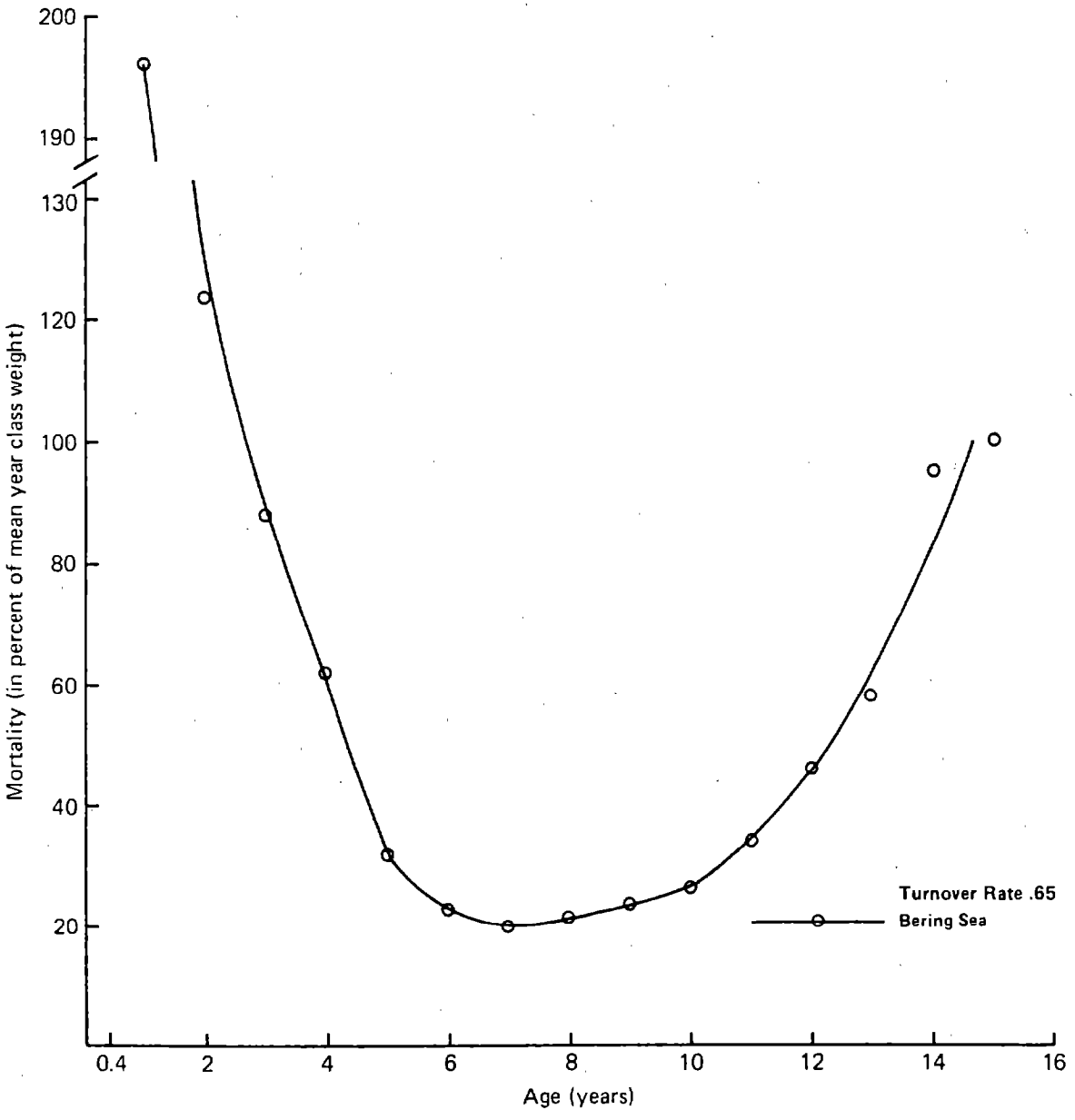
GREENLAND TURBOT
Growth rate percent per year (weight)



GREENLAND TURBOT
Distribution of biomass with age



GREENLAND TURBOT
Distribution of mortality with age



5.6 FLATHEAD SOLE (Hippoglossoides elassodon)

The available data indicate that the juveniles of flathead sole grow faster in the Gulf of Alaska than in the Bering Sea. This is expected according to available knowledge of the effect of temperature on the growth. However, the data show that the older fish grow longer and heavier in the Bering Sea. This might arise from questionable data or be caused by the migrations of older, large fish toward northern distribution boundaries.

FLATHEAD SOLE (Hippoglossoides elassodon)

	Gulf of Alaska	Bering Sea
Exploitable - age (years)	6-16	6-16
length (cm)	25-37	25-40
weight (g)	130-625	130-675
Catches - domestic	Minor fishery	Minor fishery
foreign (t)	700 (est)	25,000 (est)
Depth - distribution (m)	50-400	In winter on slope and deeper part of shelf; in summer widely distributed 60-450
fishing (m)	up to 200	Winter 90-450 Summer 110-140
Maturity - age (years)	3 ?	
length (cm)	18 ?	
Spawning - season	April-May	June-July
area	(Not localized)	(Not localized)
Fecundity	50,000-160,000	50,000-160,000
At a turnover rate of .65		
Exploitable biomass, %	41.1	42.8
Juvenile biomass, %	58.9	57.2
Growth rate, % per month		
Whole population	4.0	4.0
Juveniles	5.9	5.8
Adults	1.2	1.6
Deceased	5.5	5.3

Notes on food composition: Most important food items - ophiarids, shrimps, amphipods, fish, mollusks.

AGE-LENGTH-WEIGHT KEY

Flathead sole (Hippoglossoides elassodon)

Age	Bering Sea		Gulf of Alaska	
	Length[1/] cm	Weight[2/] g	Length[3/] cm	Weight[4/] g
1	9.3	11.0	9.3	10.5
2	14.1	25.8	14.1	25.0
3	17.5	45.0	18.3	50.0
4	20.2	68.5	22.0	85.0
5	22.7	98.0	24.6	122.5
6	24.8	132.0	26.5	153.5
7	27.0	177.5	28.0	187.0
8	29.2	230.0	29.5	225.0
9	31.3	288.0	30.5	263.0
10	32.8	345.0	32.0	297.0
11	34.5	405.0	33.3	340.0
12	35.5	463.0	34.5	385.0
13	36.7	514.0	35.5	423.0
14	37.8	565.0	36.3	457.0
15	38.9	608.5	37.3	500.0
16	40.0	655.0	38.0	530.0

1/ Pereyra et al. 1976; Crab-Groundfish survey data 1971-78.

2/ Pereyra et al. 1976.

3/ Ronholt et al. 1978; M/F cruise 75-l data.

4/ Ronholt et al. 1978; M/F cruise 75-l data; RACE survey data.

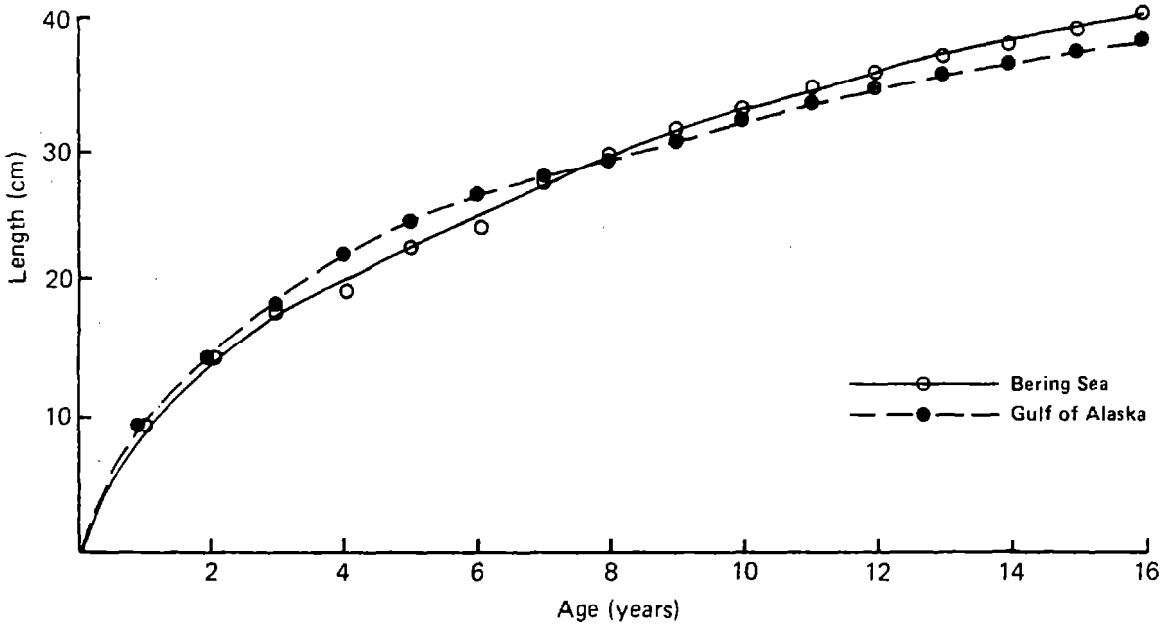
LENGTH-WEIGHT KEY

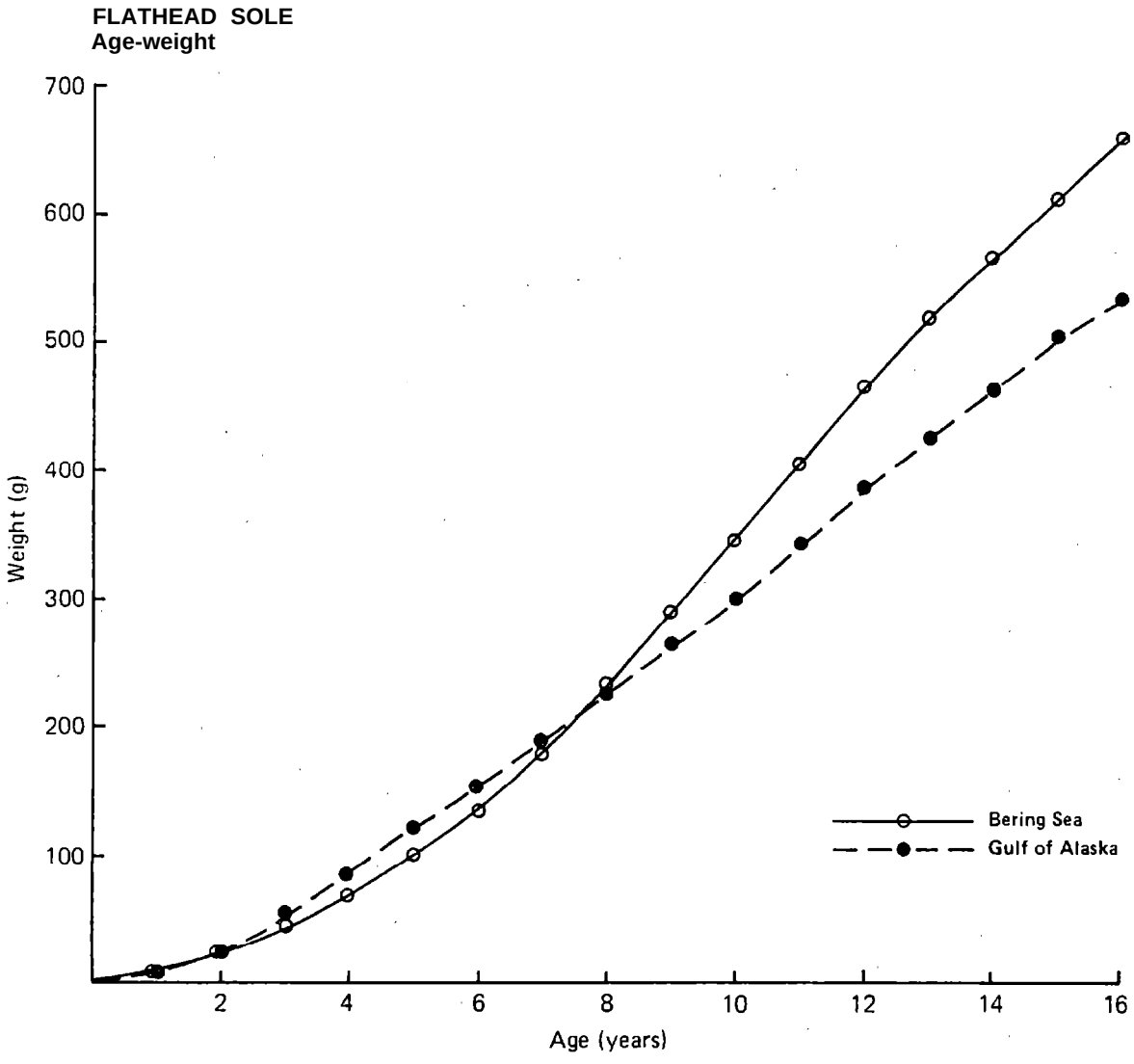
Flathead sole (Hippoglossoides elassodon)

{Calculated from age-length and age-weight data)

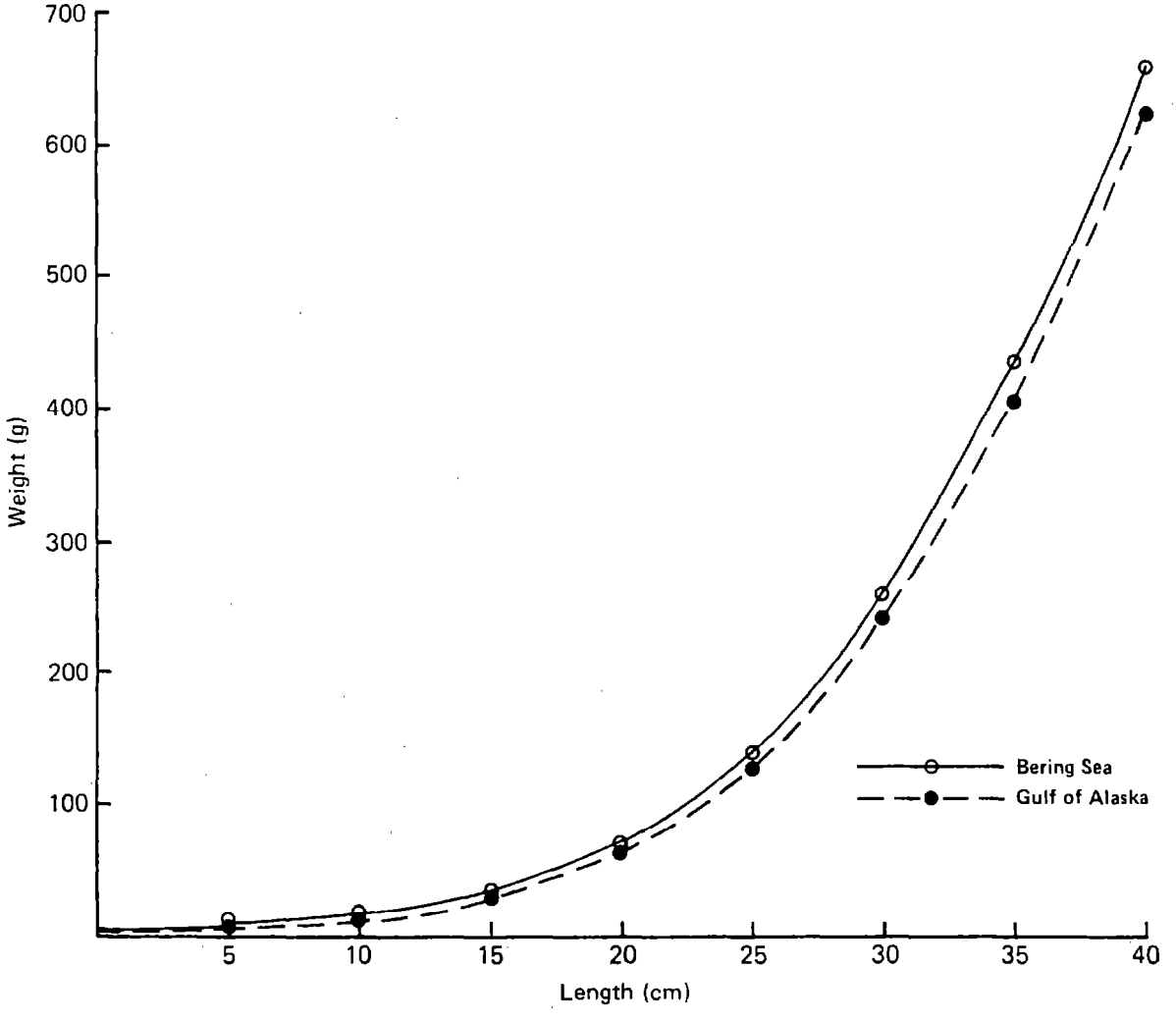
Length cm	Bering Sea Weight g	Gulf of Alaska Weight g
5	5.0	4.5
10	15.0	13.0
15	31.5	27.5
20	67.5	65.0
25	137.5	127.5
30	260.0	240.0
35	435.0	405.0
40	655.0	620.0

FLATHEAD SOLE
Age-length

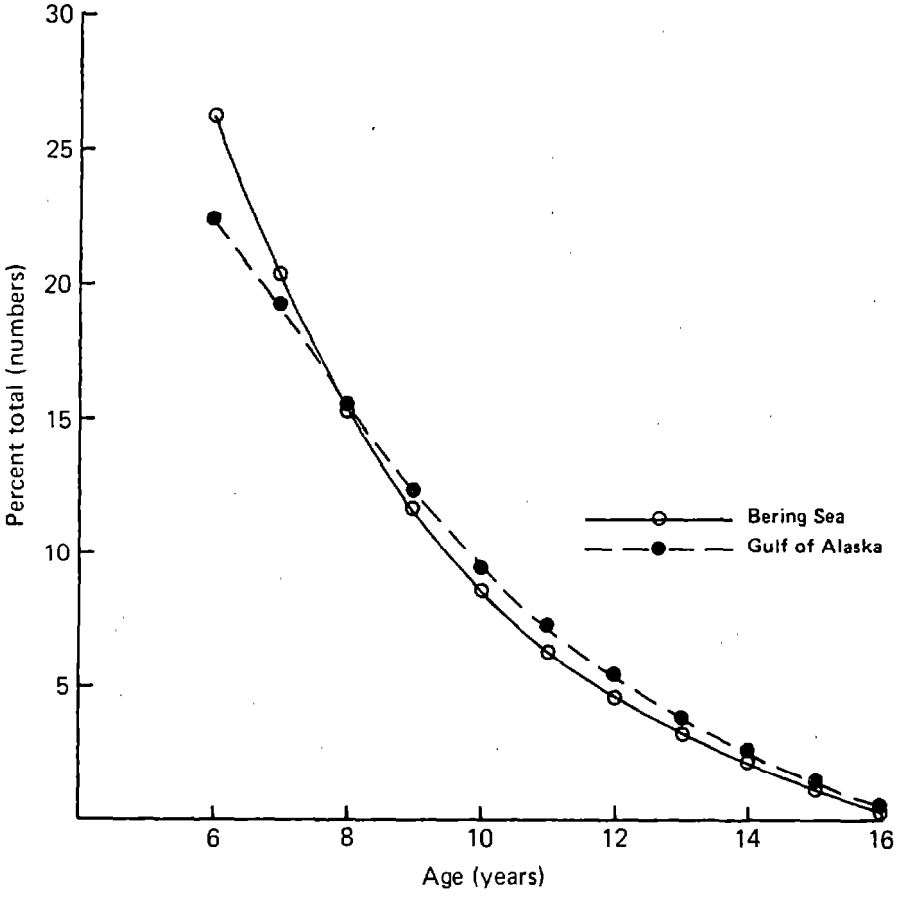



FLATHEAD SOLE
Age-weight
700
600
500
400
300
200
100
Weight (g)
2
4
6
8
10
12
14
16
Age (years)
Bering Sea
Gulf of Alaska

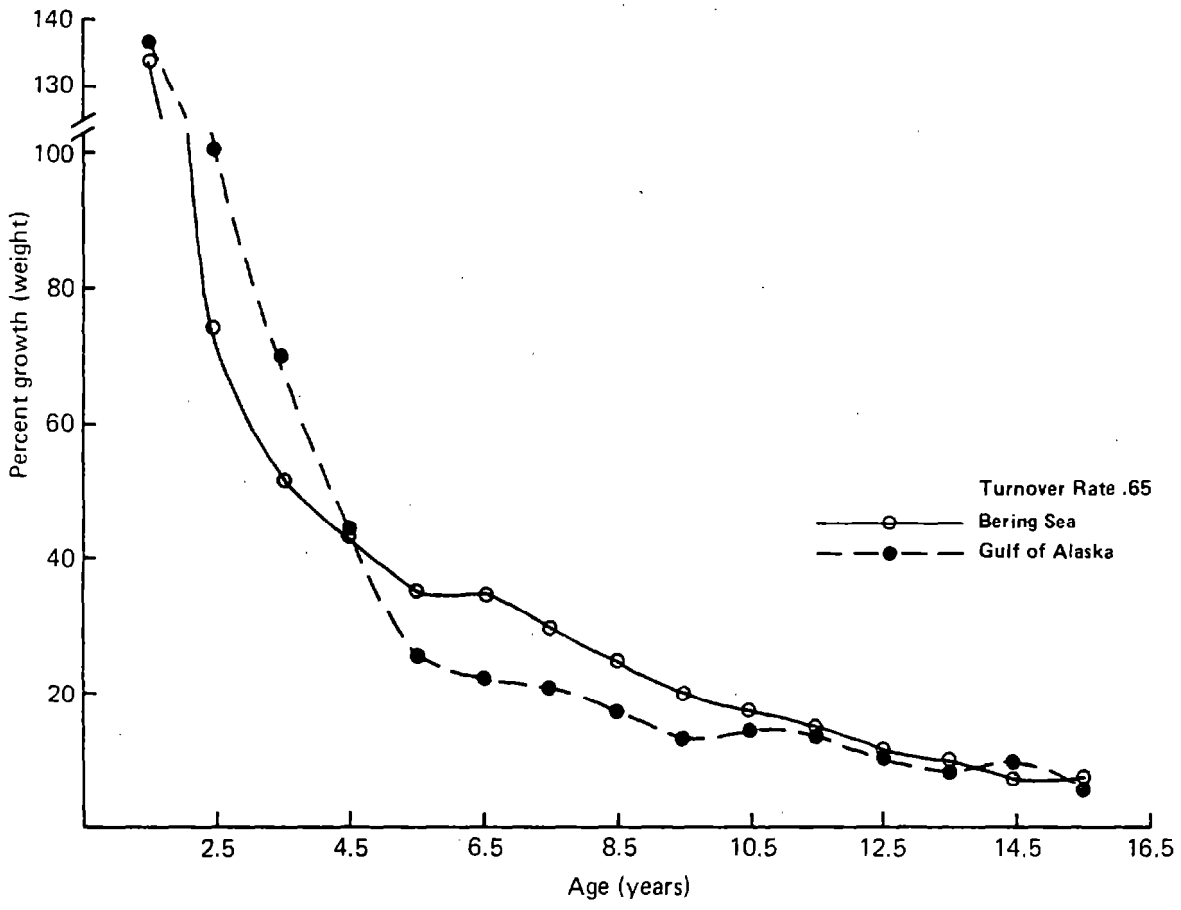
FLATHEAD SOLE
Length-weight



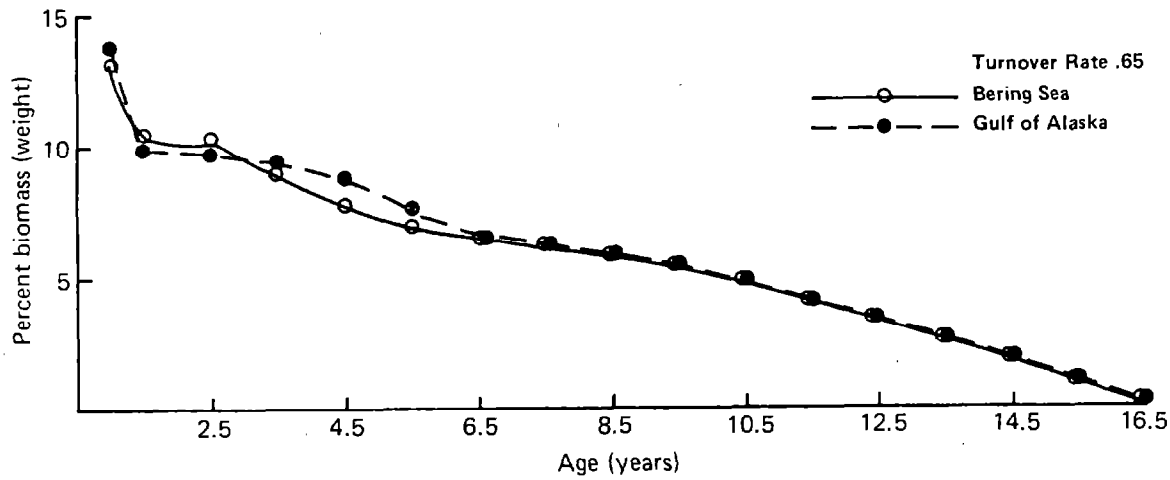
FLATHEAD SOLE
Long term mean age composition of fully exploited year classes



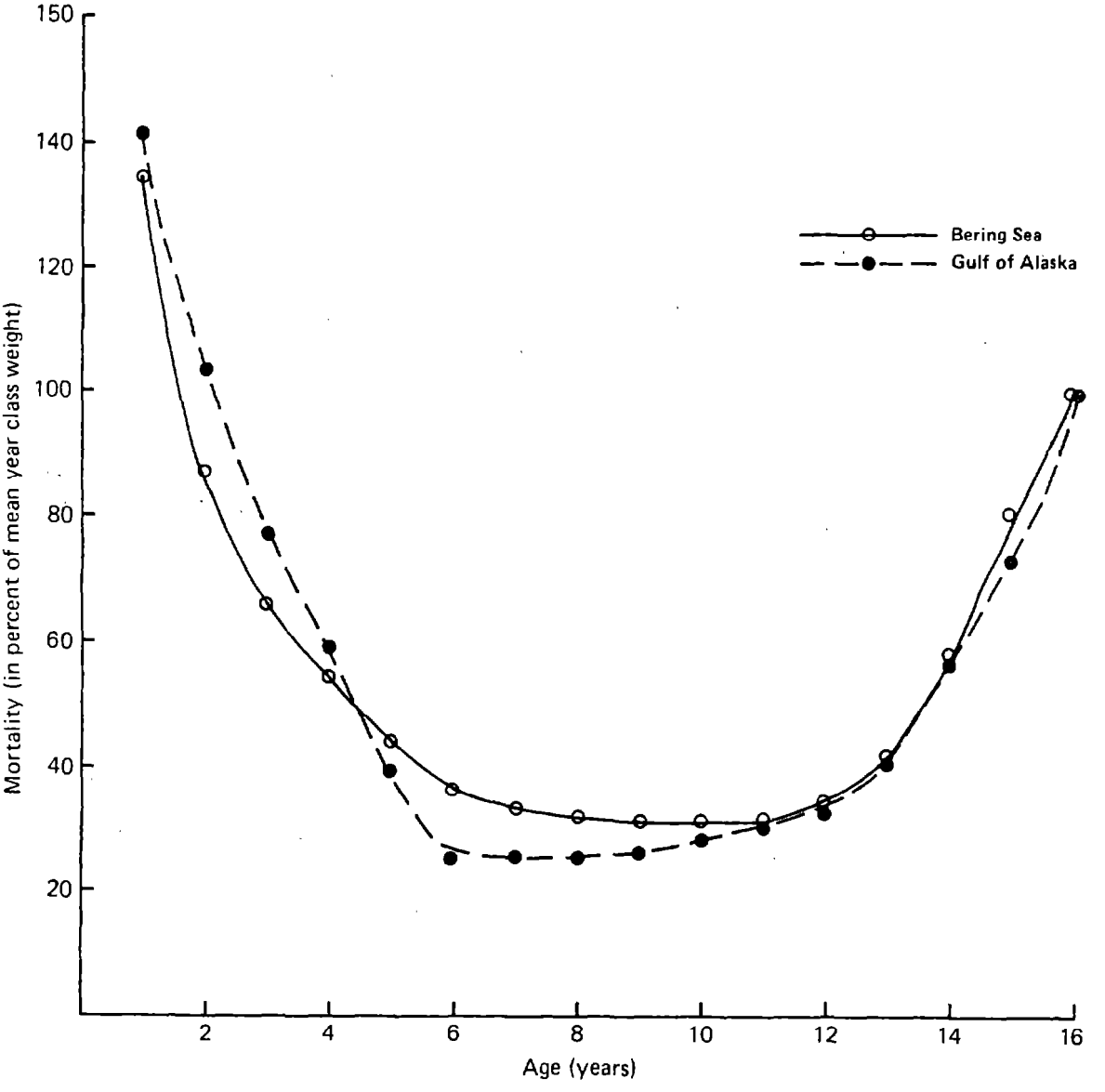
FLATHEAD SOLE
Growth rate percent per year (weight)



FLATHEAD SOLE
Distribution of biomass with age



FLATHEAD SOLE
Distribution of mortality with age



5.7 ROCK SOLE (Lepidopsetta bilineata)

The unpublished length-weight-age data from the Gulf of Alaska (NOAA ship Miller Freeman cruises) are variable and in some cases show even slower growth of the species in the Gulf of Alaska than in the Bering Sea.

On the other hand, Levings (1967) gives slightly higher length-at-age values for Bristol Bay and Gulf of Alaska than the data presented in this summary, which are adjusted down with the unpublished data from NWAFC.

Furthermore, Levings (1967) and Forrester and Thomson (1969) give considerably higher values of length at age in Northern Hecate Strait. This indicates the presence of a separate local, fast growing (higher temperature) stock in this strait. The data of this stock are excluded from the present summary.

The differences in the age of full recruitment to the fishery between the two areas is influenced by the type of fishery and availability (migrations) of the fish as well as the occurrence of this species as bycatch in some fisheries.

ROCK SOLE (Lepidopsetta bilineata)

	Gulf of Alaska	Bering Sea
Exploitable-age (years)	5-14	6 - 1 4
length (cm)	22-35	25-40
weight (g)	100-800	150-900'
Catches-domestic (t)	Minor fishery	Minor fishery
foreign (t)	900	3 6 , 0 0 0
Depth-distribution (m)	20-300	50-400 ?
fishing (m)	20-100 winter 20-50 summer	39-300
Maturity-age (years)	4-6	5-7
length (cm)	male 18 female 28	male 20 ? female 30 ?
Spawning-season	March to June	March to June
area	Around Kodiak Isl.	SW of St. Matthews Isl. on wintering grounds
Fecundity	Average 200,000	150,000 to 400,000
At a turnover rate of .65		
Exploitable biomass.,%	56.1	49.0
Juvenile biomass,%	43.9	51.0
Growth rate, % per month		
Whole population	3.9	3.9
Juveniles	6.4	5.9
Adults	2.0	1.8
Deceased	5.3	5.2

Notes on food composition: Most important food items-polychaetes, mollusks, crustaceans (mostly shrimp), and occasionally sand lances.

AGE-LENGTH-WEIGHT KEY

Rock sole (Lepidopsetta bilineata)

Age	Bering Sea		Gulf of Alaska	
	Length[1/] cm	Weight[2/] g	Length[3/] cm	Weight[4/] g
1	8.3	8.5	6.7	8.5
2	12.7	23.5	12.0	23.5
3	16.1	41.5	16.0	38.5
4	18.9	71.5	20.0	61.5
5	21.4	106.0	22.5	94.0
6	23.7	148.0	24.3	136.0
7	26.0	198.0	26.4	190.0
8	28.4	262.5	27.5	253.5
9	30.7	332.0	28.9	325.0
10	32.8	415.0	30.0	404.5
11	34.7	508.5	31.4	483.0
12	36.6	610.0	32.5	580.0
13	38.3	706.0	33.5	675.0
14	39.8	810.0	34.4	765.0

1/ Crab-groundfish survey 1971-78; Levings 1967; Qbseryer Program 1974-78

2/ M/F cruises 77-l and 78-3; Pereyra et al, 1976.

3/ Crab-groundfish survey 1971-78; Levings 1967; Observer Program 1974-78; Forrester end Thompson 1969,

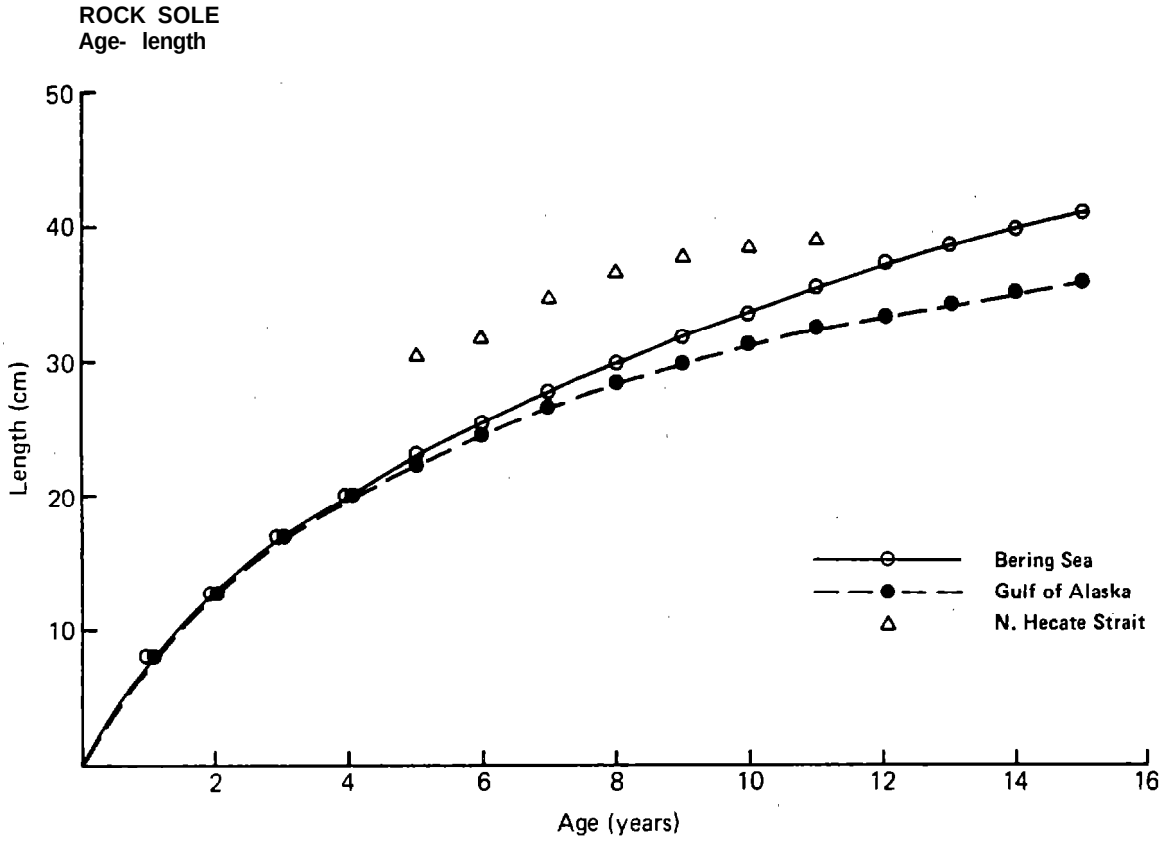
4/ Pereyra et al. 1976; Fadeev 1965; Observer Program 1974-78,

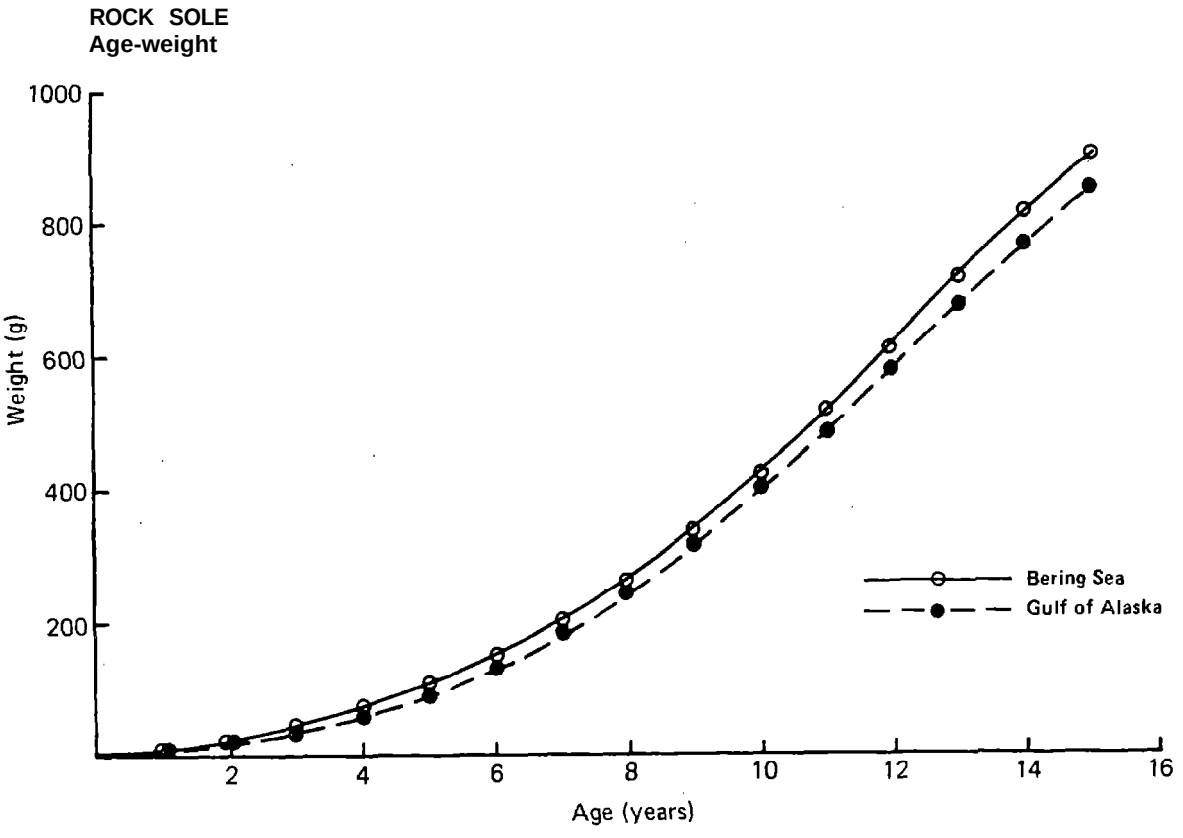
LENGTH-WEIGHT KEY

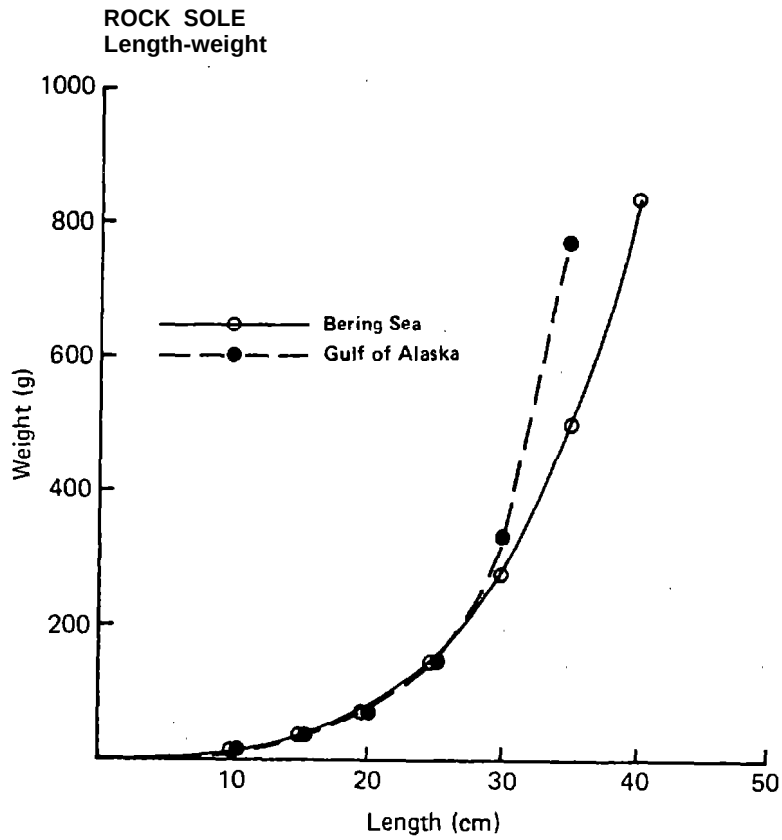
Rock sole (Lepidopsetta bilineata)

(Calculated from age-length and age-weight data)

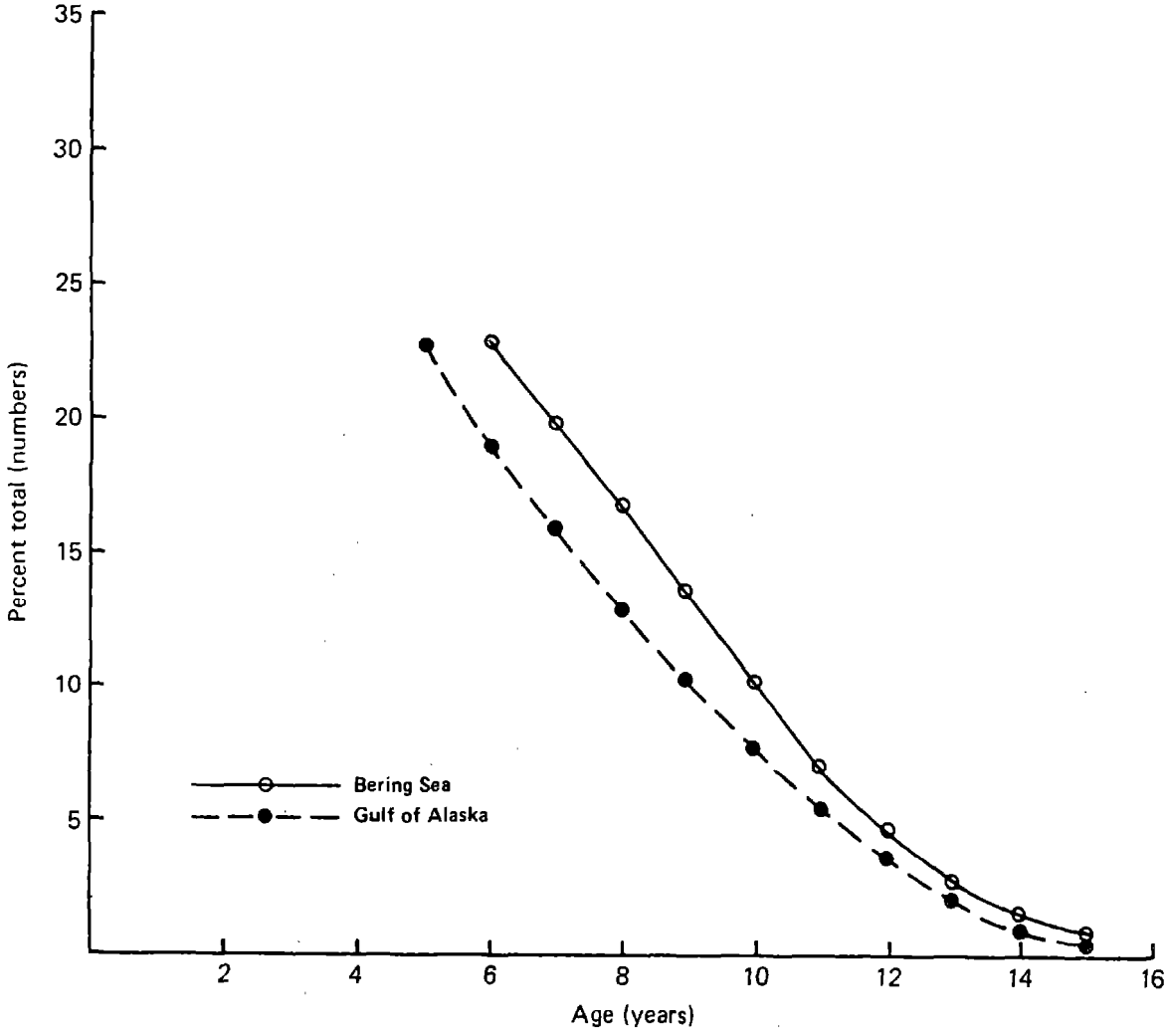
Length cm	Bering Sea Weight	Gulf of Alaska Weight
5		
10		
15		
20		
25		
30		
35		
40		


ROCK SOLE
Age- length
Length (cm)
50
40
30
20
10
2
4
6
8
10
12
14
16
Age (years)
Bering Sea
Gulf of Alaska
N. Hecate Strait

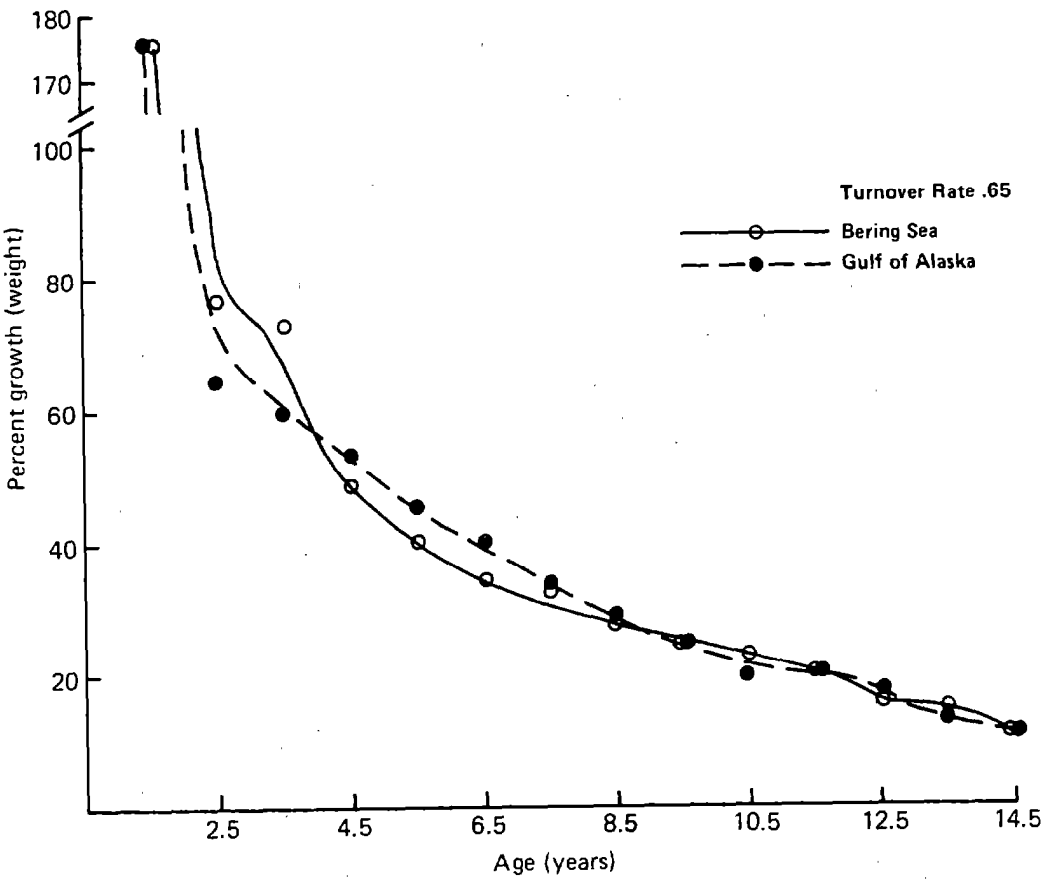

ROCK SOLE
Age-weight
1000
800
600
400
200
Weight (g)
2
4
6
8
10
12
14
16
Age (years)
Bering Sea
Gulf of Alaska


ROCK SOLE
Length-weight
1000
800
600
400
200
Weight (g)
Bering Sea
Gulf of Alaska
10
20
30
40
50
Length (cm)

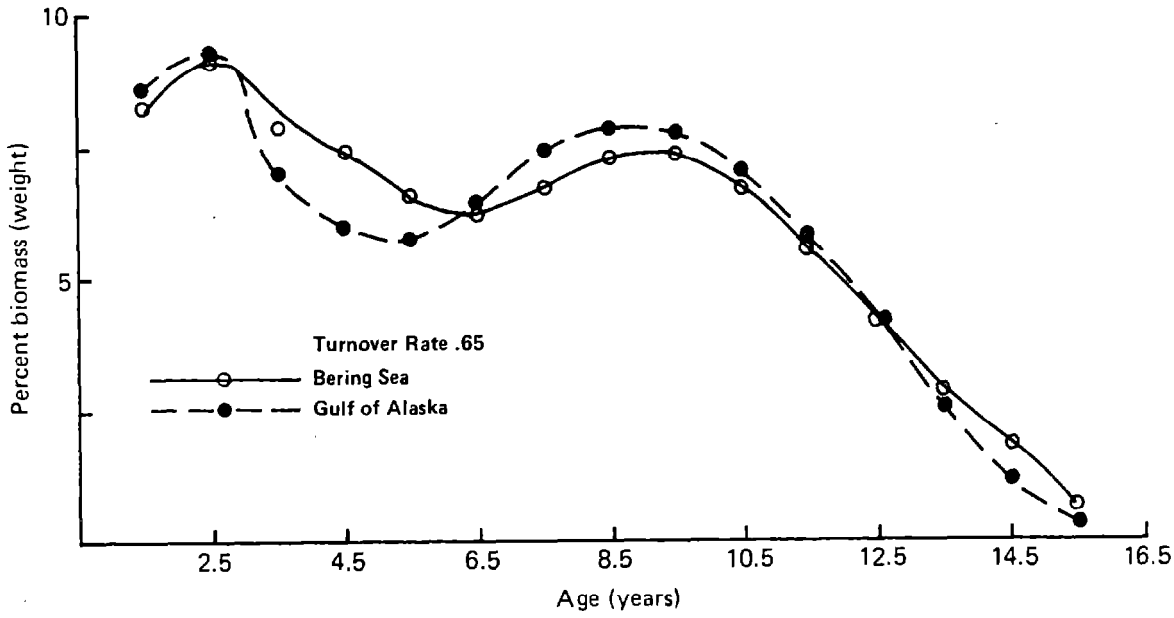
ROCK SOLE
Long term mean age composition of fully exploited year classes



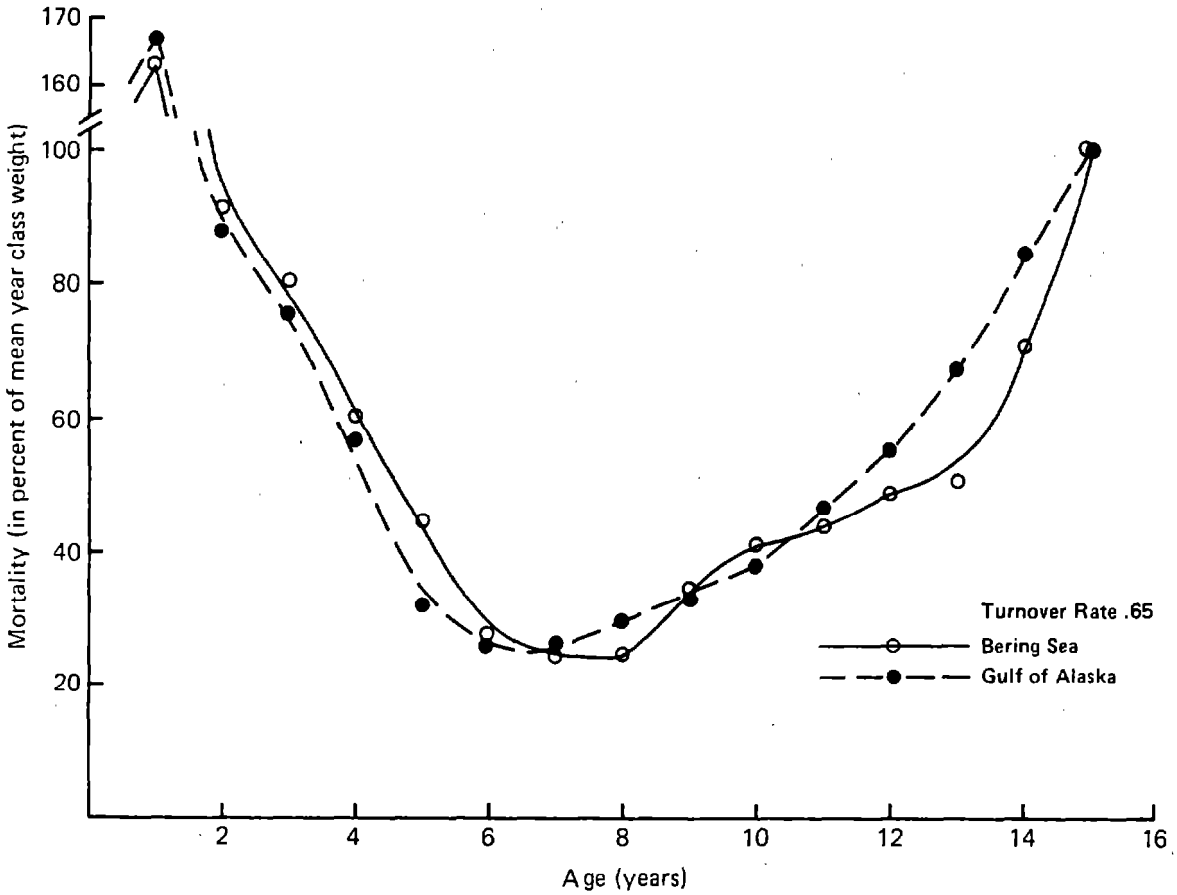
ROCK SOLE
Growth rate percent per year (weight)



ROCK SOLE
Distribution of biomass with age



ROCK SOLE
Distribution of mortality with age



5.8 PACIFIC OCEAN PERCH (Sebastes alutus)

The length and weight at age of this species are nearly identical in the Gulf of Alaska and in the Bering Sea, indicating that the same stock inhabits both regions. (The growth rate of Pacific ocean perch caught off the Canadian coast and southward has, however, considerably higher growth rate, belonging to another stock.)

The age (and size) composition of catches from the Bering Sea shows that older and larger specimens occur in this region. This seems to be in conformity with general phenomena that older and larger specimens accumulate at the colder boundaries of general distribution. For this reason the fully exploited year class in the Bering Sea is 11 years old whereas in the Gulf of Alaska 7-year-olds are fully exploited.

The data on maturity and spawning areas and times are meager for Pacific ocean perch.

PACIFIC OCEAN PERCH (Sebastes alutus)

	Gulf of Alaska	Bering Sea
Exploitable - age (years)	7 to 20	11 to 20
length (cm)	25 to 40	30 to 40
weight (g)	250 to 850	500 to 850
Catches - domestic (t) 1/	20	50
foreign (t) 1/	12,500	15,000
Depth - distribution (m) 2/	180 to 3000 summer	160 to 3000 summer
	275 to 3000 winter	300 to 3000 winter
fishing (m)	180 to 300	150 to 350
Maturity - age (years)	4 to 6	4 to 8
length (cm)	20 to 30	20 to 30
Spawning - season	March to June	March to May
area	Deep water >300 m	Deep water >300 m
Fecundity	10,000 to 68,000	27,000 to 180,000
At a turnover rate of .65		
Exploitable biomass,%	44.0	18.5
Juvenile biomass,%	56.0	81.5
Growth rate, % per mos.		
Whole population	3.7	3.7
Juveniles	5.6	4.4
Adults	1.2	0.7
Deceased	6.4	6.3

Notes on food composition: Most important food items - copepods, euphausids, shrimp, squid, smelts, myctophids, other fish.

1/ Provisional estimates for 1980 (Murai et al. 1981)

2/ Some parts of Pacific Ocean perch population migrates and feeds over deep water.

AGE-LENGTH-WEIGHT KEY

Pacific Ocean perch (Sebastes alutus)

Age	Bering Sea		Gulf of Alaska	
	Length[1/] cm	Weight[2/] g	Length[3/] cm	Weight[4/] g
1	7.2	5.0	7.1	5.5
2	12.0	20.0	11.8	22.5
3	16.0	51.0	16.0	54.5
4	18.9	85.0	19.1	90.5
5	21.5	130.5	21.7	135.0
6	24.0	178.0	24.2	185.0
7	26.6	230.0	26.7	240.0
8	27.8	295.0	28.1	310.0
9	29.2	353.0	30.2	370.0
10	31.0	420.0	31.5	440.0
11	32.2	393.5	32.4	515.0
12	33.5	555.0	33.9	582.5
13	34.5	620.0	35.0	640.0
14	35.5	670.0	35.8	695.0
15	36.2	725.0	36.7	745.0
16	37.1	767.5	37.5	795.0
17	37.8	802.0	38.2	830.0
18	38.5	824.0	39.0	855.5
19	39.0	843.0	39.6	872.0
20	40.0	852.0	40.6	890.0

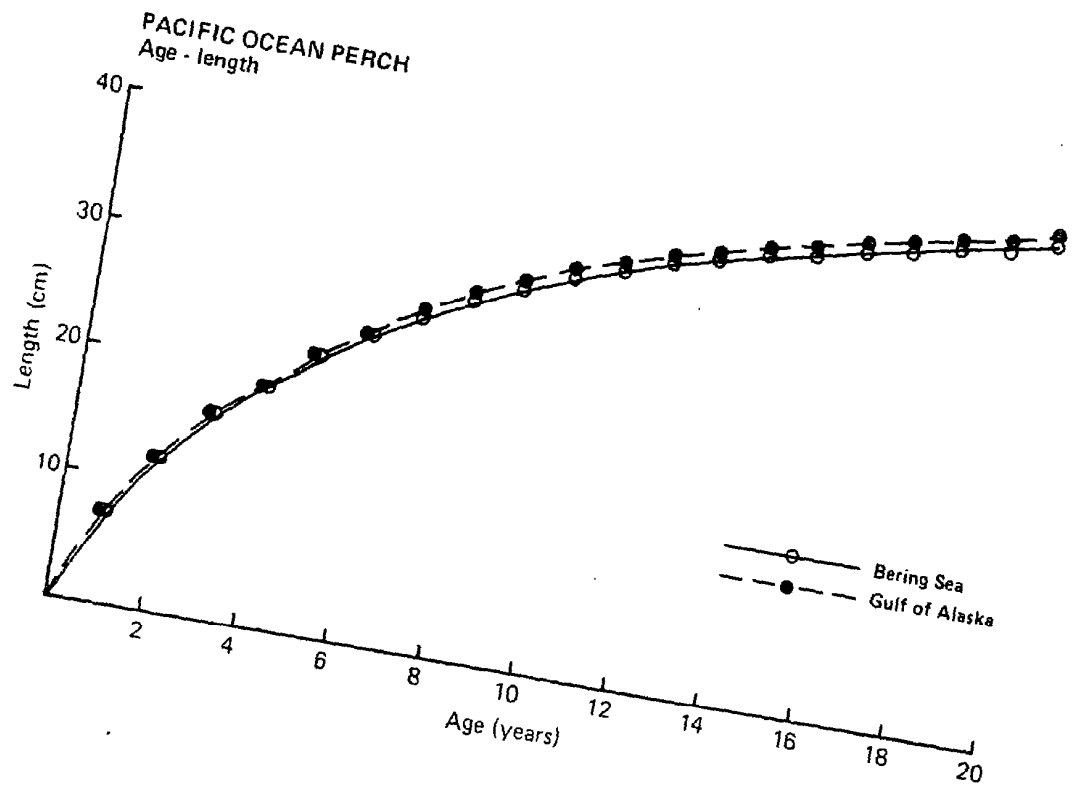
1/ Pereyra et al. 1976; Major and Shippen 1970; Paraketsov 1963.
2/ Pereyra et al. 1976; Observer Program 1976-79; Major and Shippen 1970: Pautov 1972; Paraketsov 1963.
3/ Groundfish survey 1979-80; Westerheim 1975; Chikuni 1975.
4/ Groundfish survey 1979-80; Ronholt, Shippen and Brown 1978.

LENGTH-WEIGHT KEY

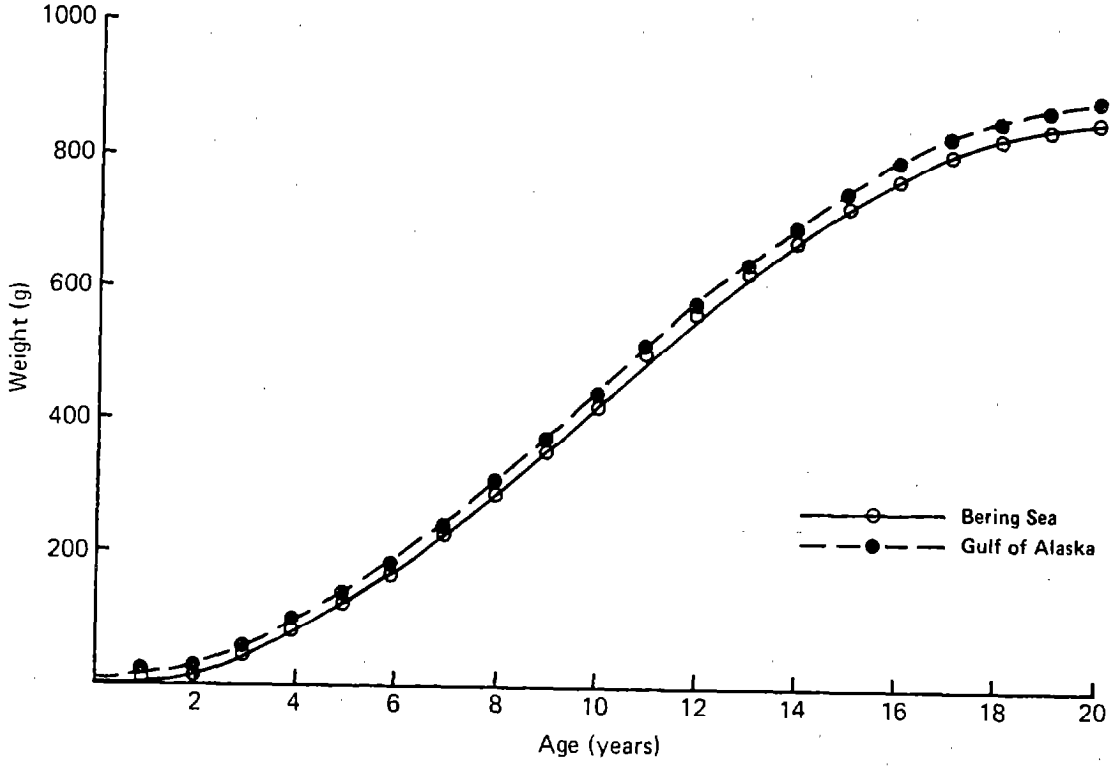
Pacific Ocean perch (Sebastes alutus)

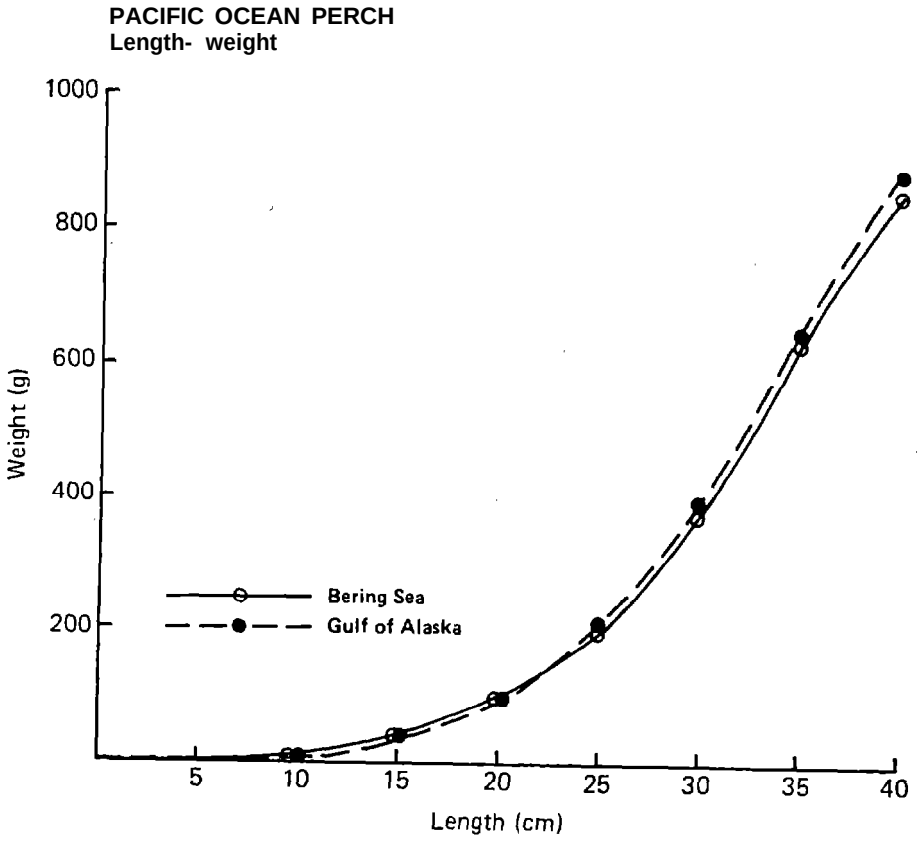
(Calculated from age-length and age-weight data)

Length cm	Bering Sea Weight g	Gulf of Alaska Weight g
5	2.5	2.5
10	10.0	10.0
15	40.0	42.5
20	94.0	100.0
25	195.0	210.0
30	375.0	382.0
35	635.0	645.0
40	852.0	885.0

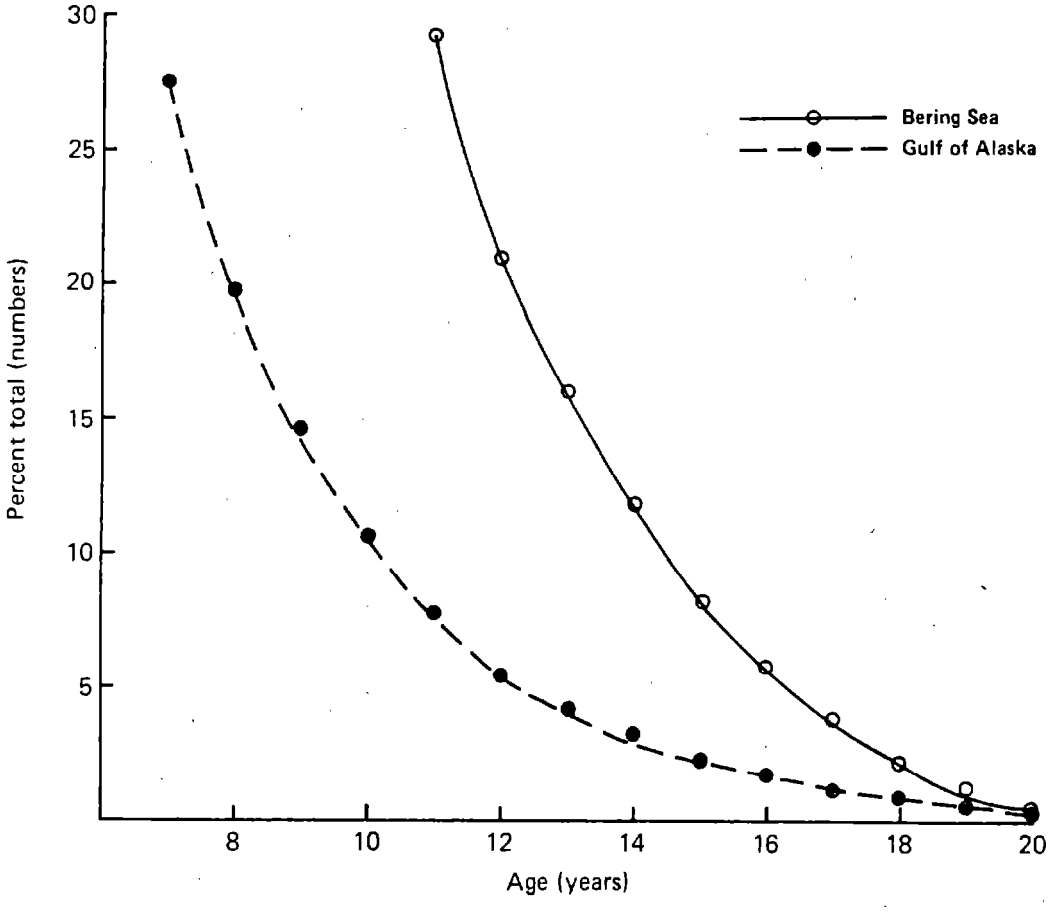

PACIFIC OCEAN PERCH
Age - length
Length (cm)
40
30
20
10
2
4
6
8
10
12
14
16
18
20
Age (years)
Bering Sea
Gulf of Alaska

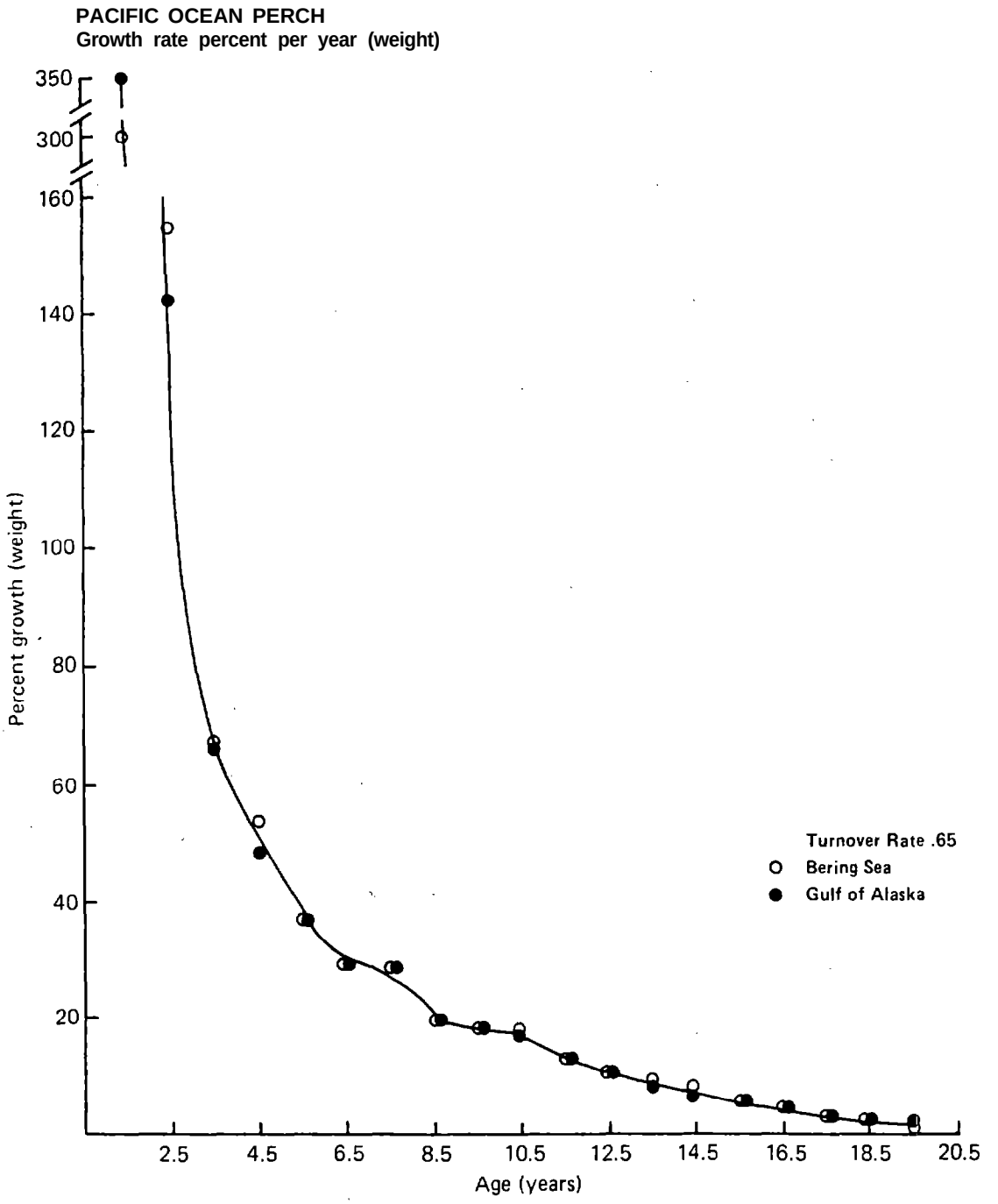
PACIFIC OCEAN PERCH
Age-weight

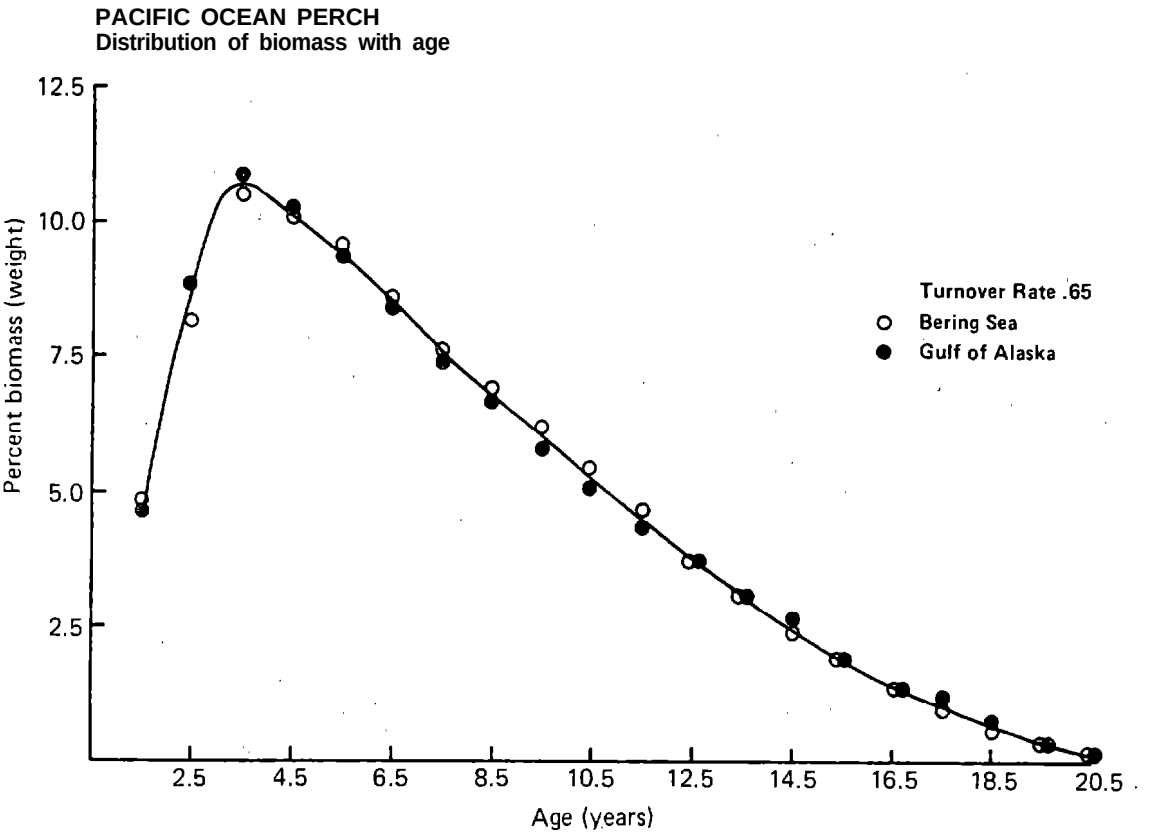



PACIFIC OCEAN PERCH
Length- weight
1000
800
600
400
200
Weight (g)
Bering Sea
Gulf of Alaska
5
10
15
20
25
30
35
40
Length (cm)

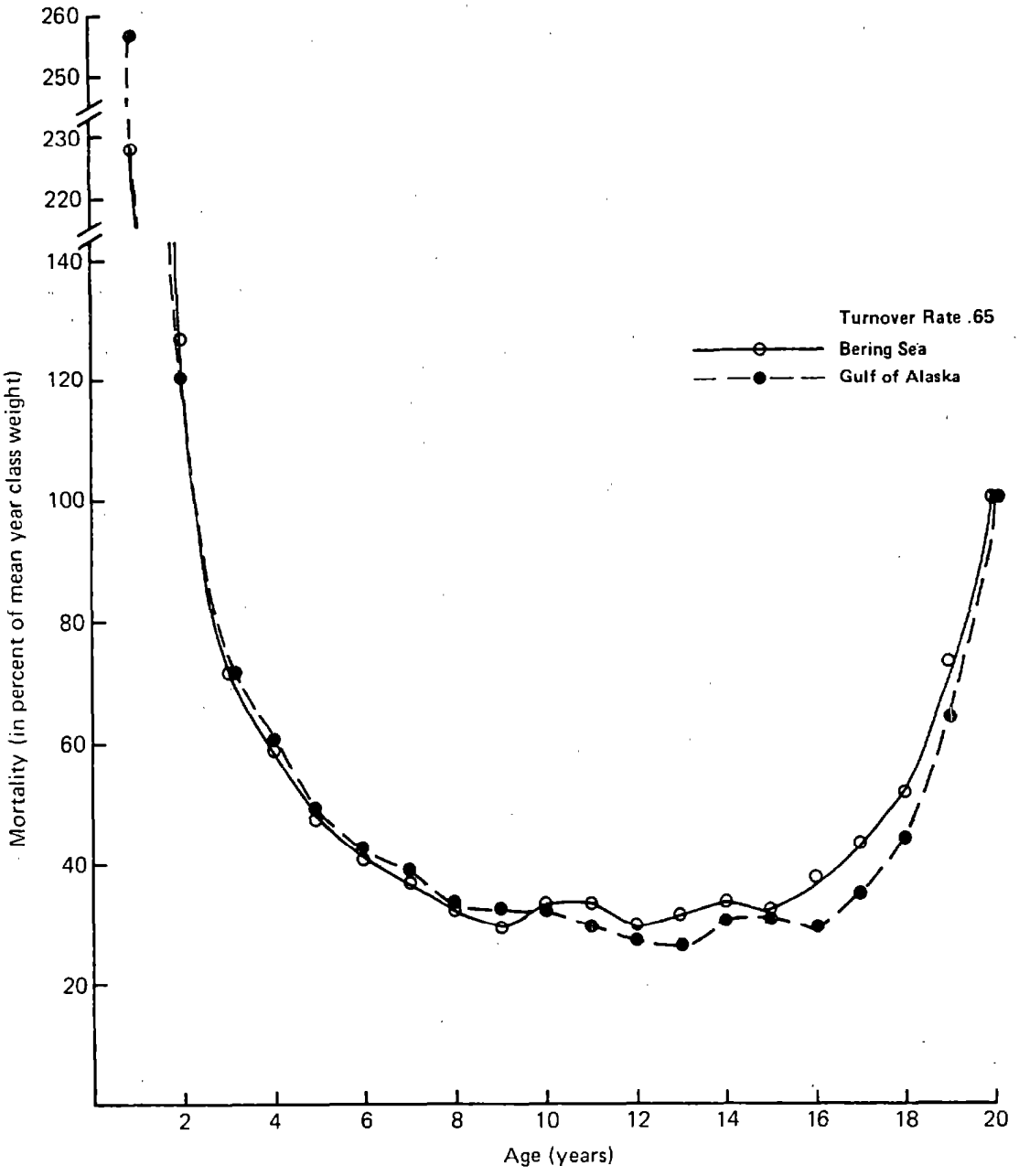
PACIFIC OCEAN PERCH
Long term mean age composition of fully exploited year classes




PACIFIC OCEAN PERCH
Growth rate percent per year (weight)
Percent growth (weight)
350
300
160
140
120
100
80
60
40
20
2.5
4.5
6.5
8.5
10.5
12.5
14.5
16.5
18.5
20.5
Age (years)
Turnover Rate .65
Bering Sea
Gulf of Alaska


PACIFIC OCEAN PERCH
Distribution of biomass with age
Percent biomass (weight)
12.5
10.0
7.5
5.0
2.5
2.5
4.5
6.5
8.5
10.5
12.5
14.5
16.5
18.5
20.5
Age (years)
Turnover Rate .65
Bering Sea
Gulf of Alaska

PACIFIC OCEAN PERCH
Distribution of mortality with age



5.9 ATKA MACKEREL (Pleurogrammus monopterygius)

Doubts can be expressed about the age determination of Atka mackerel, especially age 1. The weight at age data of this species are also questionable. Consequently the computed data pose the same questions as the basic input data.

ATKA MACKEREL (Pleurogrammus monopterygius)

	'Gulf of Alaska,	Bering Sea
Exploitable - age (years)	2 to 6	2 to 6
length (cm)	25 to 38	20 to 35
weight (g)	300 to 600	200 to 500
Catches - domestic (t)[1/]	3	265
foreign(t)[1/]	13,162	20,255
Depth - distribution	(Northern Gulf of Alaska)	(Southern part of Bering Sea
fishing (m)	110 to 250	70 to 150
Maturity - age (years)	3	3
length (cm)	ca 33	ca 33
Spawning - season	June, July, August	June, July, August
area	Passes between Atka and Amlia Island, Atka and Adak Islands, Umnak and Unalaska, Shumagin Island.	
Fecundity	5,000 to 43,000	5,000 to 43,000
At a turnover rate of .65		
Exploitable biomass,%	55.3	51.7
Juvenile biomass,%	44.7	48.3
Growth rate,% per month		
Whole population	4.1	3.9
Juveniles	6.9	6.4
Adult	1.8	1.6
Deceased	3.8	4.0

Notes on food composition: Plankton, small fish, mollusks, worms, and hydroids.

l/ Provisional estimates for 1980 (Murai et al. 1981).

AGE-LENGTH-WEIGHT KEY

Atka mackerel (Pleurogrammus monopterygius)

Age	Bering Sea		Gulf of Alaska	
	Length[1/] cm	Weight[2/] g	Length[3/] cm	Weight[4/] g
1	20.6	150.0	22.8	162.5
2	27.1	275.1	30.0	308.0
3	31.0	374.3	33.5	425.0
4	32.7	438.5	35.3	502.0
5	33.8	482.0	36.2	550.0
6	34.6	515.0	36.8	580.0
7	35.0	545.0	37.0	602.0

1/ Summary of observer data 1977-79

2/ Summary of observer data 1977-79

3/ Low et al. 1979. Survey cruise data 1981.

4/ Survey cruise data (raw). Survey cruise data 1981.

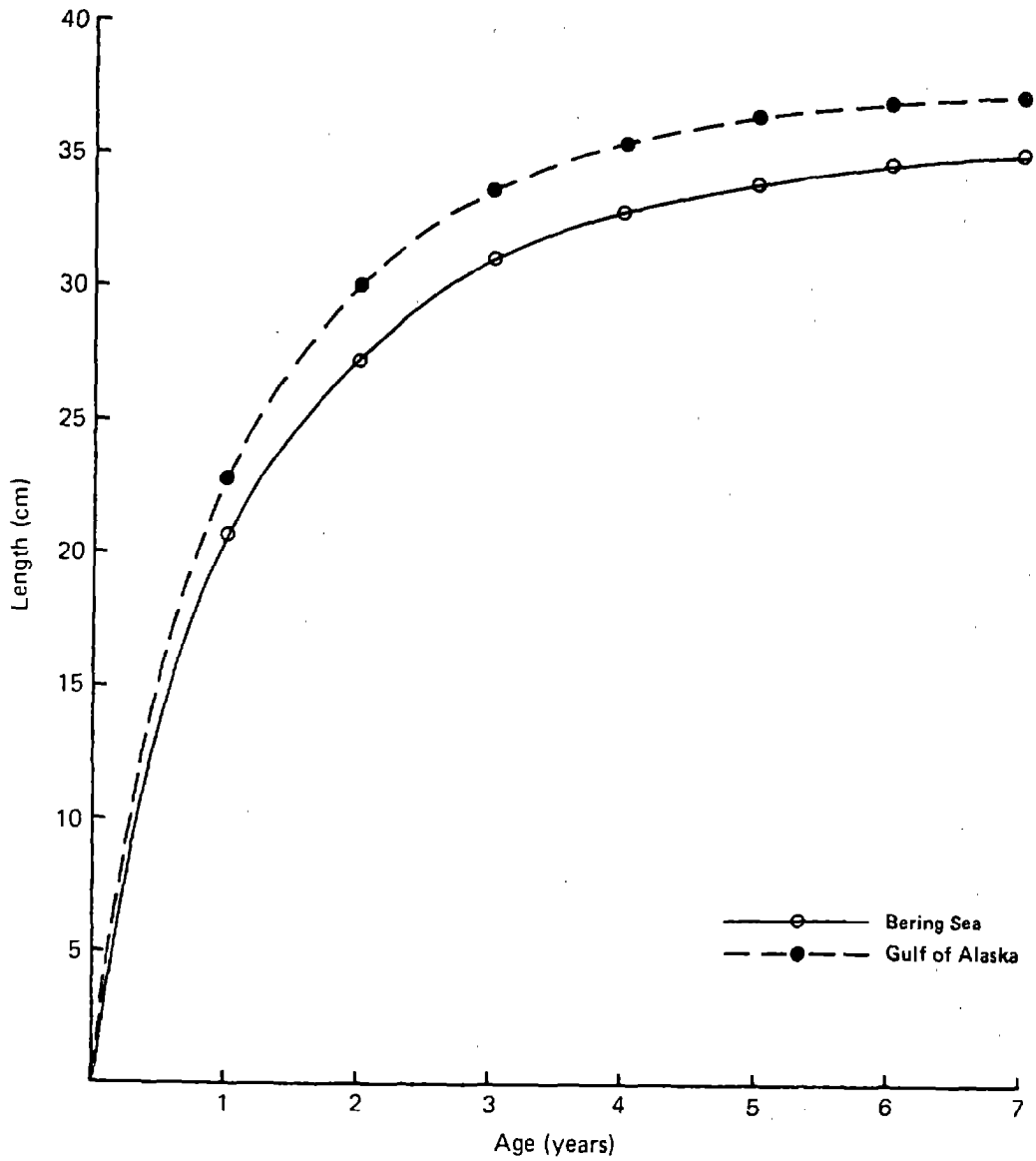
LENGTH-WEIGHT KEY

Atka mackerel (Pleurogrammus monopterygius)

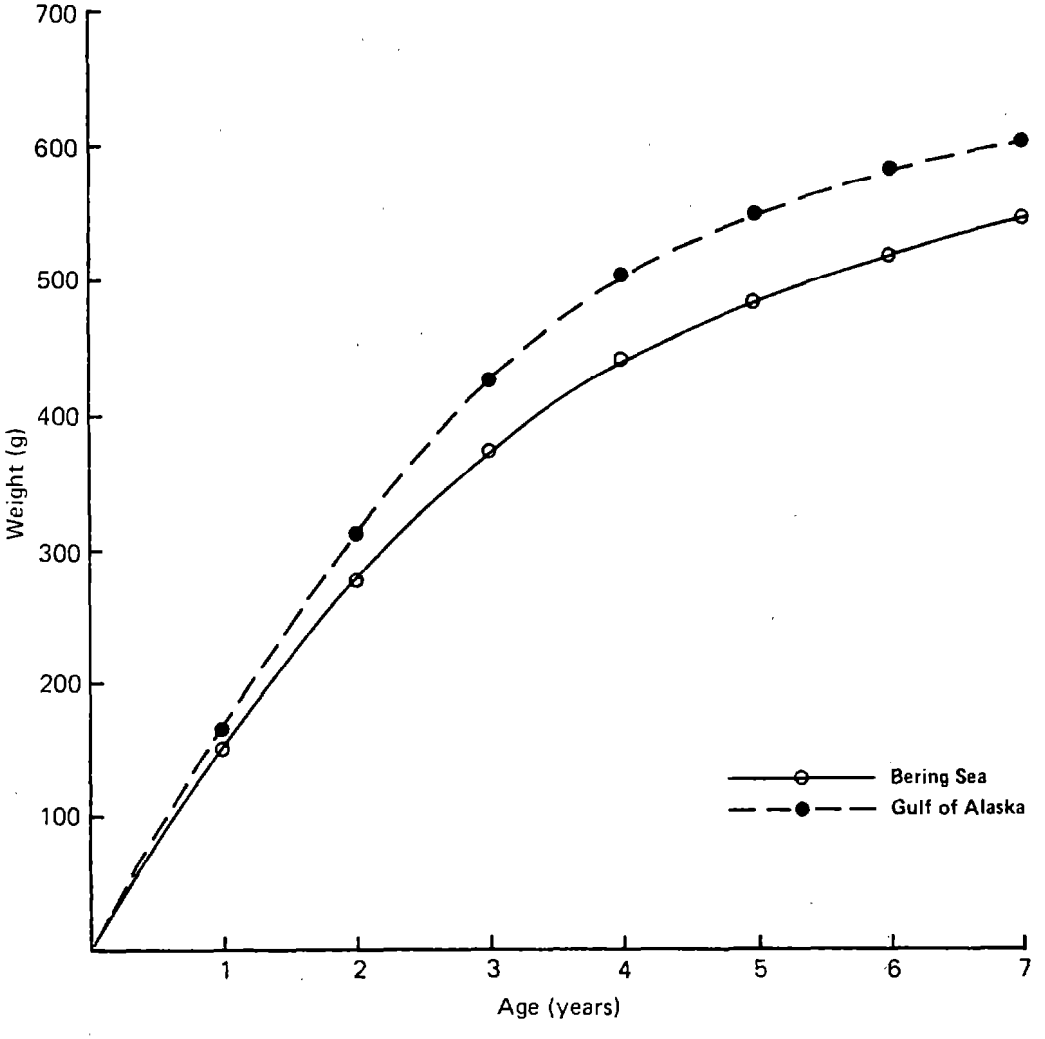
(Calculated from age-length and age-weight data)

Length cm	Bering Sea Weight g	Gulf of Alaska Weight g
5	18.0	18.0
10	45.0	45.0
15	90.0	85.0
20	145.0	132.5
25	226.0	200.0
30	341.5	310.0
35	545.0	490.0

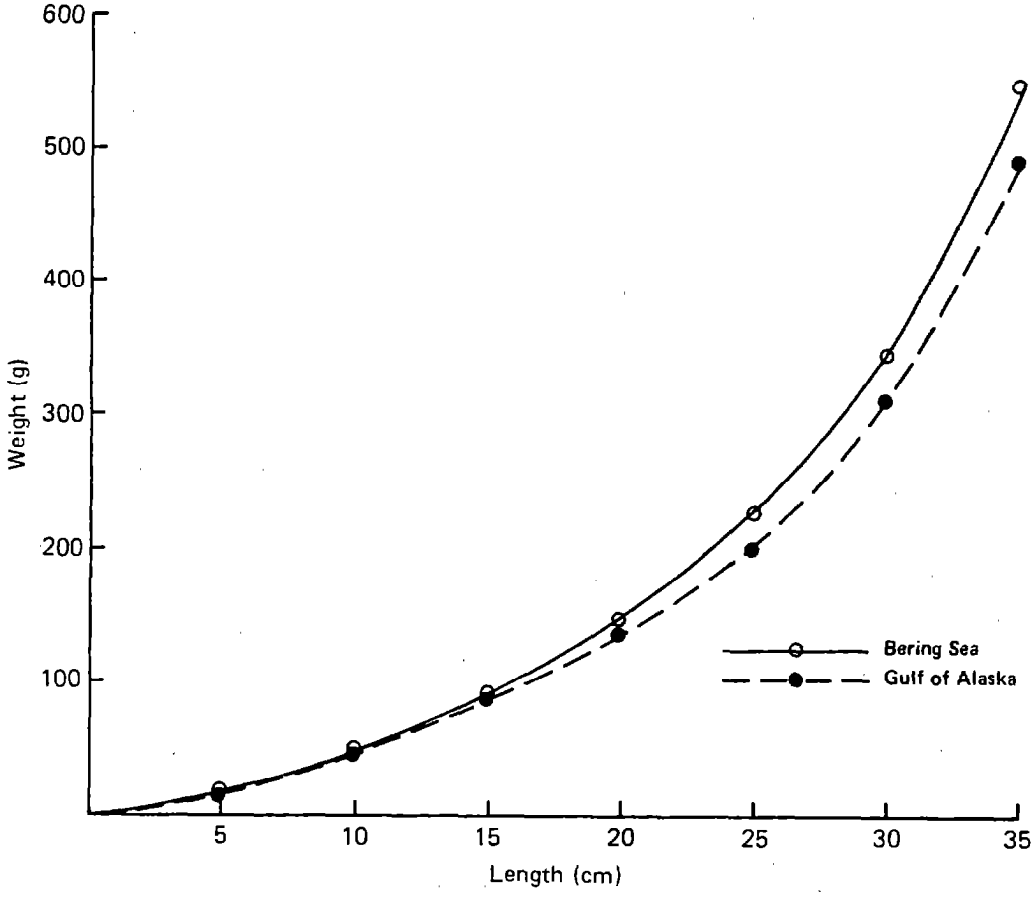
ATKA MACKEREL
Age- length



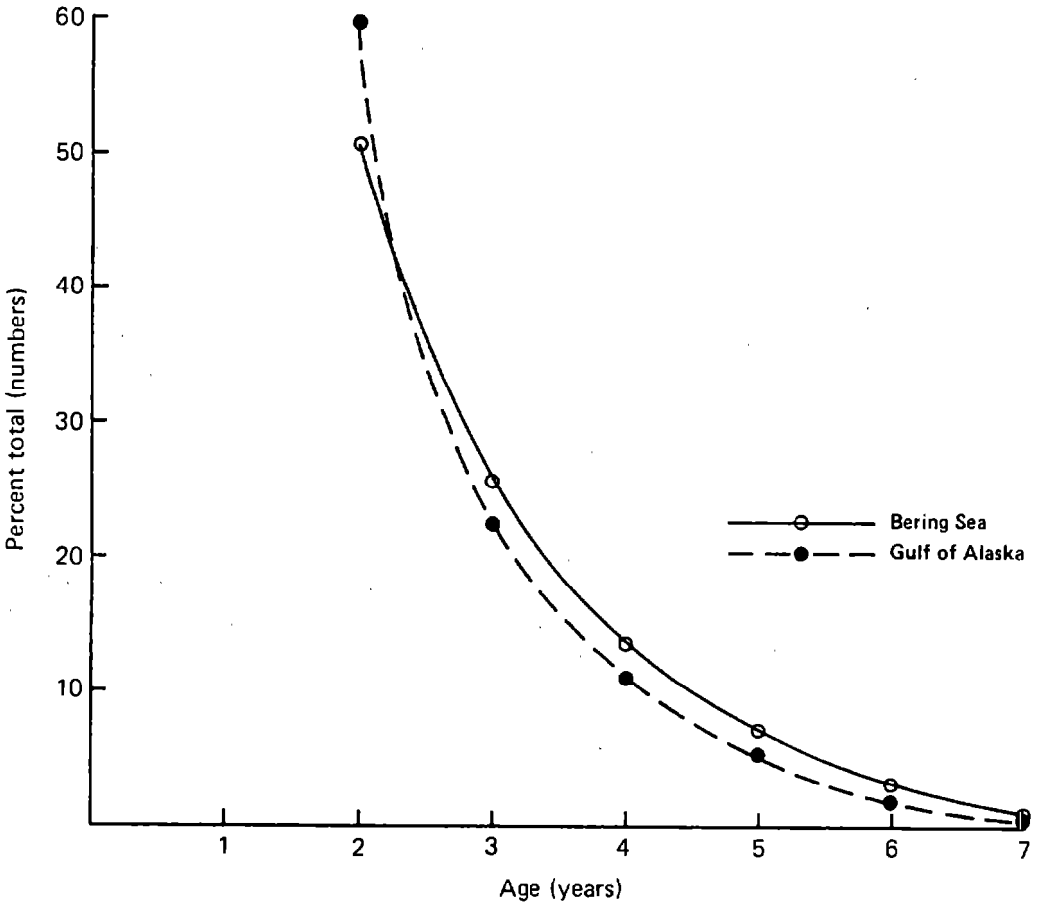
ATKA MACKEREL
Age-weight
Gulf of Alaska



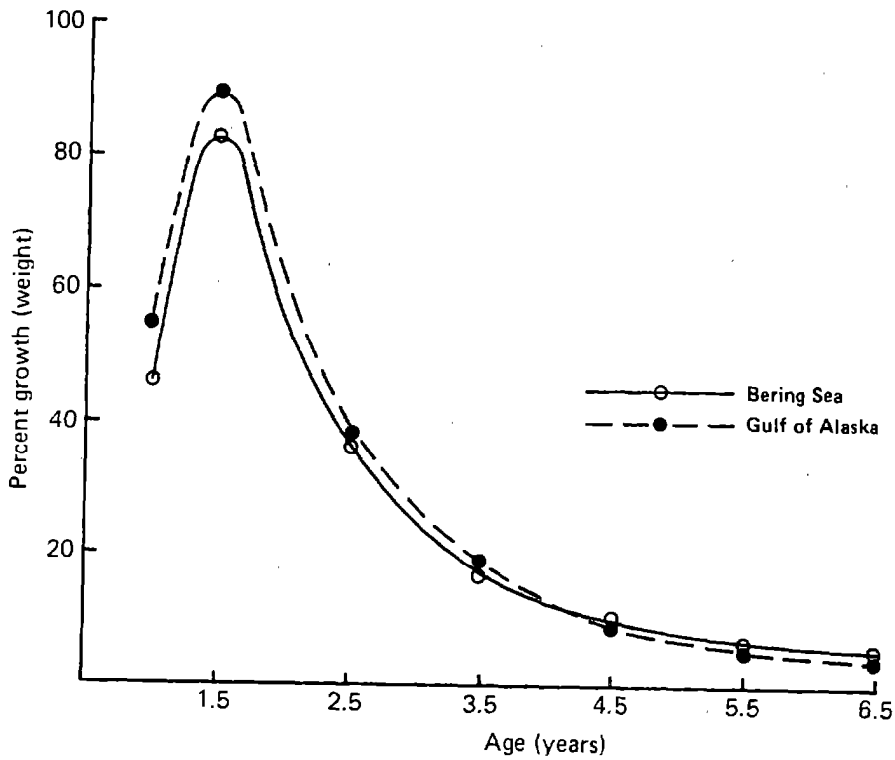
ATKA MACKEREL
Length-weight



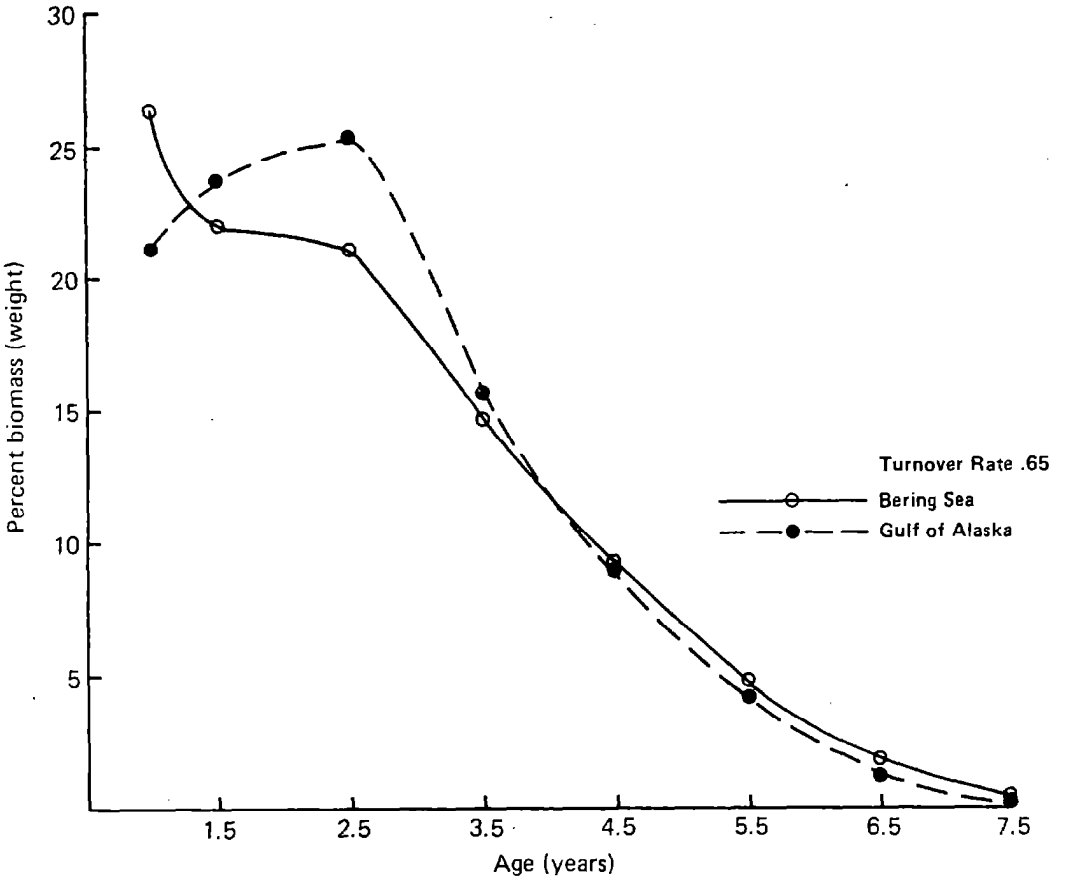
ATKA MACKEREL
Long term mean age composition of fully exploited year classes



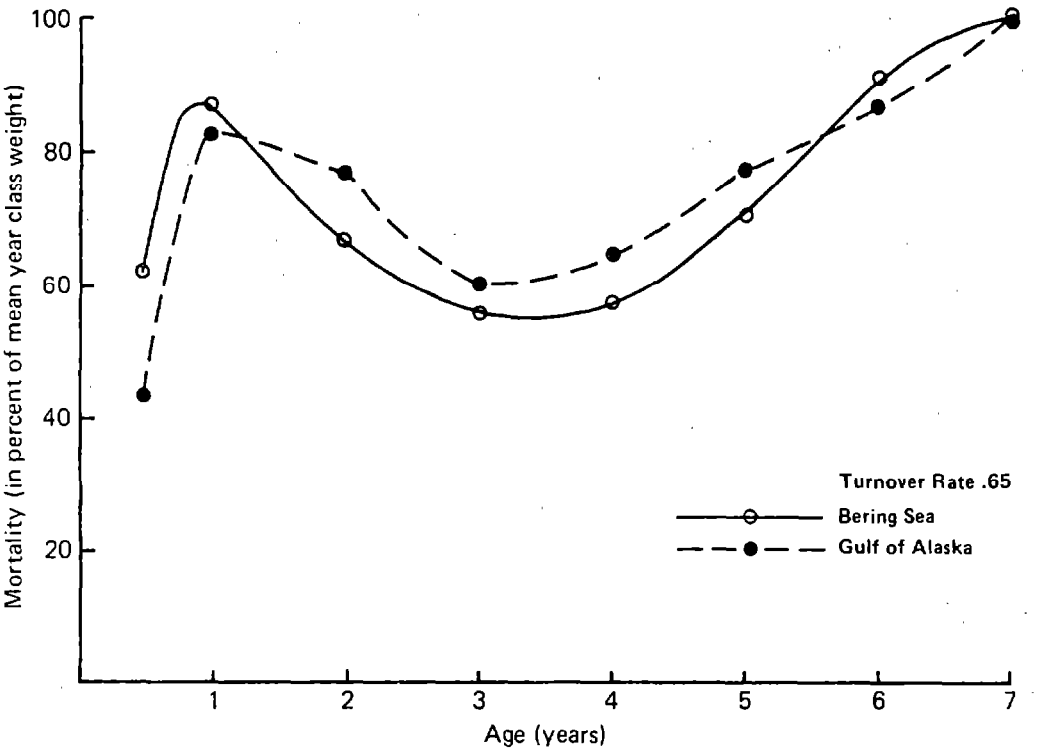
ATKA MACKEREL
Growth rate percent per year (weight)



ATKA MACKEREL
Distribution of biomass with age



ATKA MACKEREL
Distribution of mortality with age



5.10 PACIFIC HERRING (Clupea harengus pallasi)

There are local races of herring which have different growth rates. In the Bering Sea there are two races--the slower growing race in Norton Sound and the faster growing Bering Sea herring. The latter seems to undertake considerable seasonal migrations.

There are several local races of herring in the Gulf of Alaska which seem to have similar growth rates. Some earlier data from the Kodiak area indicate the presence of faster growth herring which might be a local race or Bering Sea herring which have migrated from Unimak Pass.

PACIFIC HERRING (Clupea harengus pallasii)

	Gulf of Alaska	SE Bering Sea
Exploitable - age (years)	(3) 4 - 9	(3) 4-9
length (cm)	18-24	22-30
weight (g)	80-220	l00-380
Catches - domestic (t)[1/]	9,000	7,000
foreign (t)[1/]	?	8,500
Depth - distribution	Continental shelf	Continental slope and shelf
fishing	Coastal areas	Coastal areas
Maturity - age (years)	3	3
length (cm)	18	20
Spawning - season	March - April	May - July
area	Coastal zone, bays	Bristol Bay to Kotzebue Sound, protected areas
Fecundity	12,000 to 80,000	26,000 to 70,000
At a turnover rate of .90		
Exploitable biomass,%	35.4	44.3
Juvenile biomass,%	64.6	55.7
Growth rate, % per month		
Whole population	5.2	5.1
Juveniles	7.3	7.5
Adults	1.5	2.0
Deceased	6.6	6.4

Notes on food composition: Plankton, fish larvae, amphipods, decapods, sagittae, euphausiids, juvenile fish.

l/ Provisional estimates for 1980 (Murai et al, 1981).

AGE-LENGTH-WEIGHT KEY
Pacific herring (Clupea harengus pallasii)

	S.E. Bering Sea		Norton Sound		Gulf of Alaska	
Age	Length[1/] cm	Weigh[2/] g	Length[3/] cm	Weight[4/] g	Length[5/] cm	Weight[6/] g
1	9.8	11.3	9.8	11.3	8.9	11.8
2	15.8	37.5	14.6	34.5	14.3	37.5
3	19.5	73.0	17.5	60.5	17.5	66.3
4	22.3	113.8	19.4	88.8	19.5	96.3
5	24.5	158.8	20.9	115.3	20.8	125.0
6	26.2	205.0	21.7	141.3	21.6	151.3
7	27.5	253.3	22.3	167.5	22.4	170.0
8	28.6	301.3	22.6	193.2	22.9	185.3
9	29.5	343.8	22.9	216.5	23.2	197.5
10	30.4	377.5	23.0	237.0	23.4	207.5

1/ Barton, 1978; Shaboneev, 1965; Skud, 1963.

2/ Rumyantsev and Darda, 1970, Shaboneev, 1965

3/ Barton, 1978.

4/ Barton, 1978.

5/ Barton, 1978; Skud, 1963.

6/ Reid, 1971; Skud, 1963.

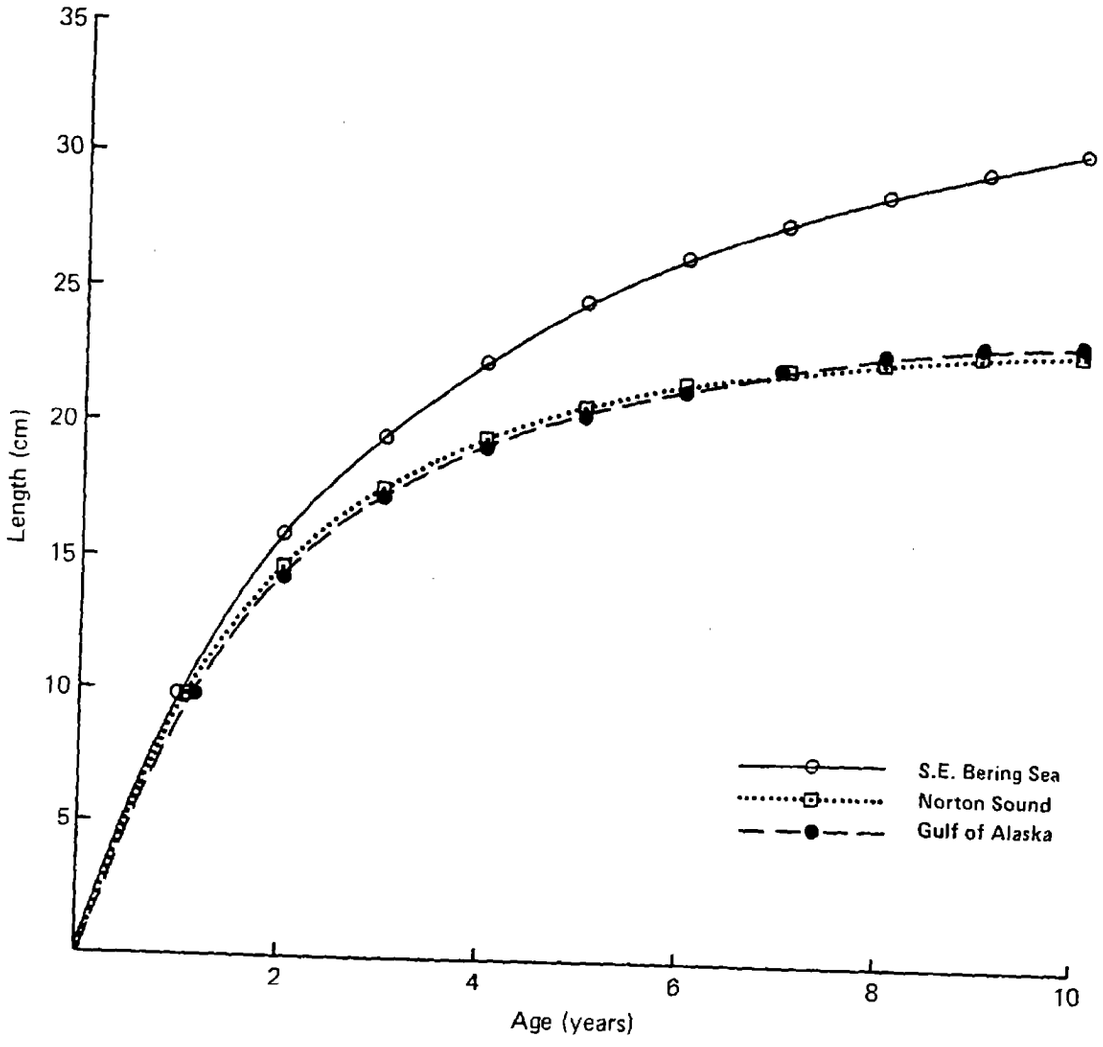
LENGTH-WEIGHT KEY

Pacific herring (*Clupea harengus pallasii*)

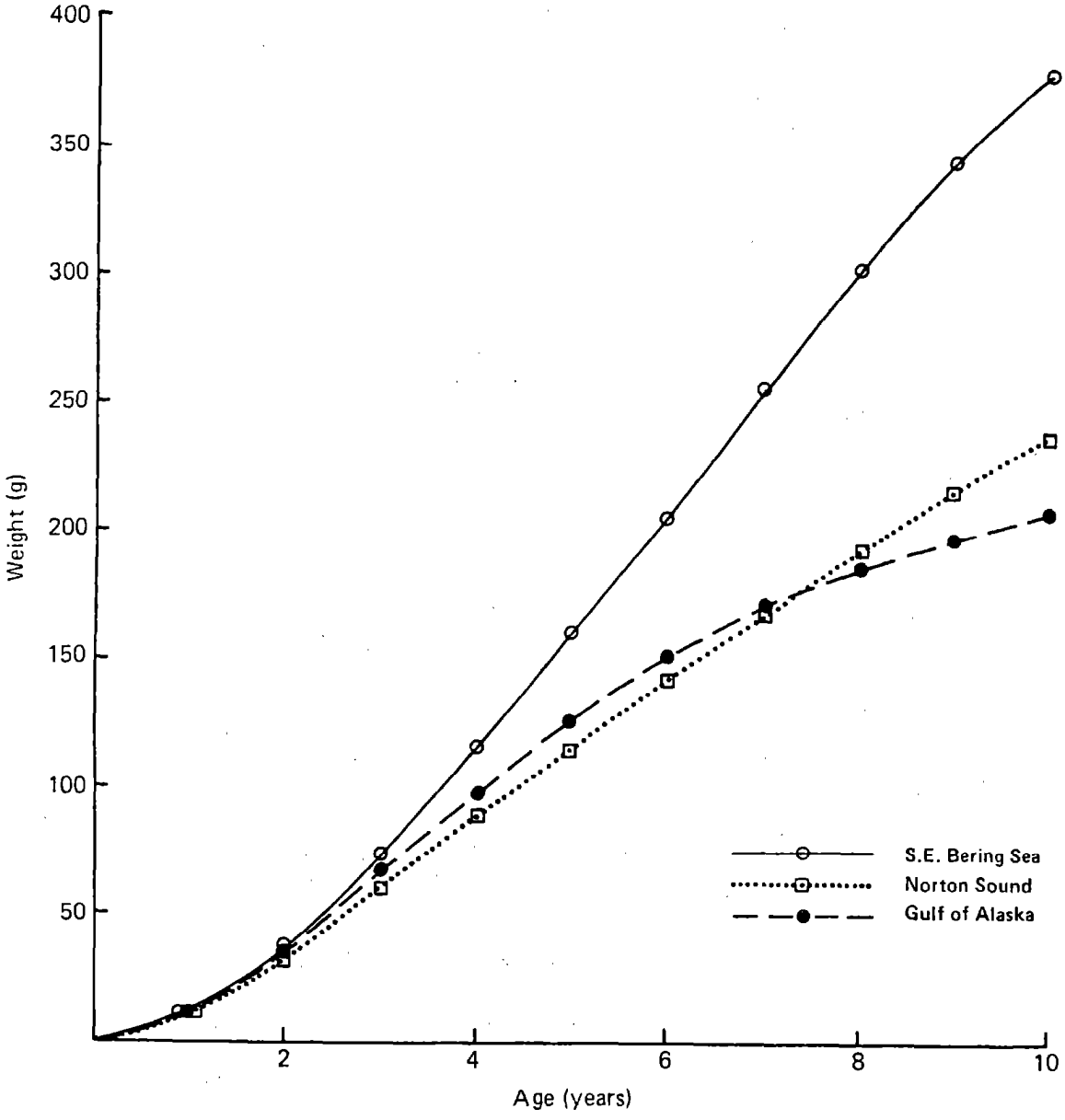
(Calculated from age-length and age-weight data)

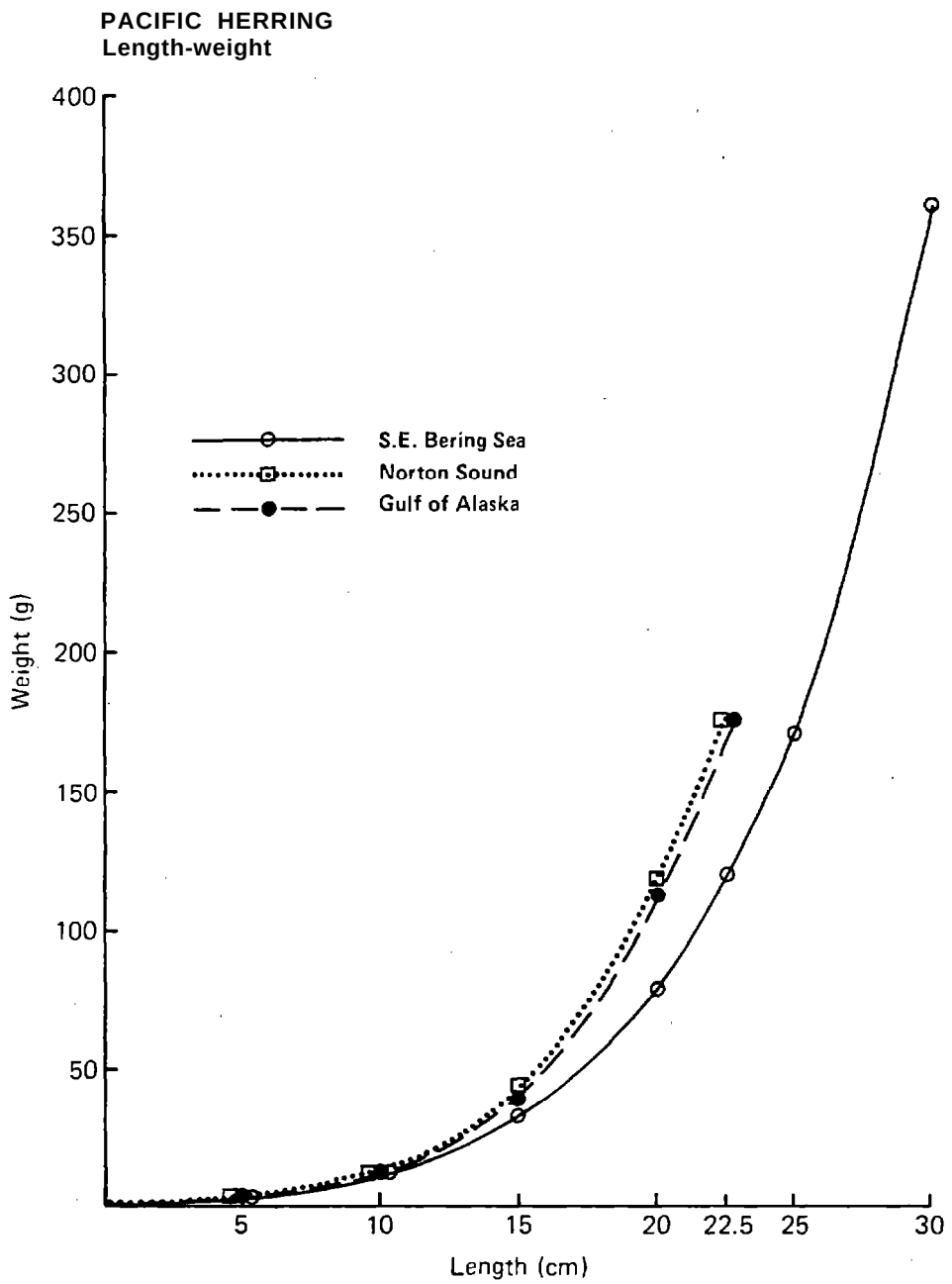
Length cm	S.E. Bering Sea Weight	Norton Sound Weight	Gulf of Alaska Weight
5	3.8	3.8	3.8
10	12.3	13.8	12.5
15	33.0	41.5	41.0
20	77.5	112.0	114.0
22.5	117.5	175.0	176.0
25	170.0		
30	360.0		

PACIFIC HERRING
Age- length

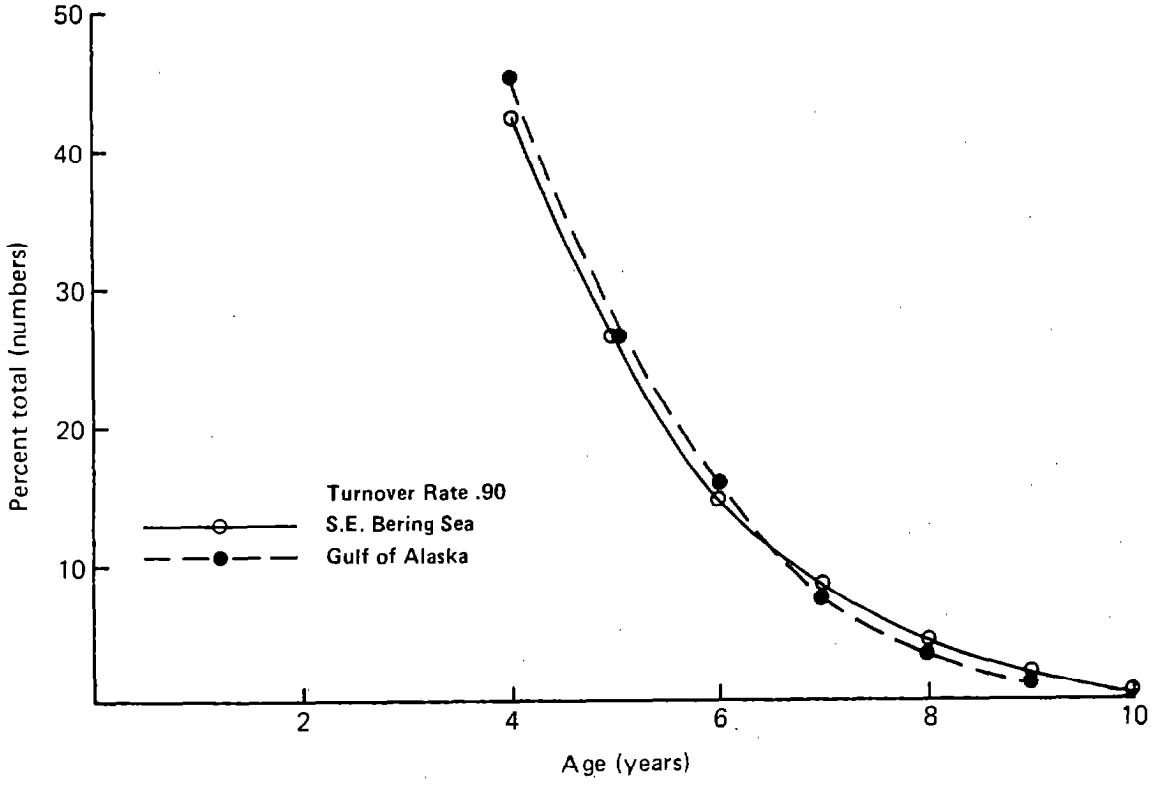


PACIFIC HERRING
Age-weight

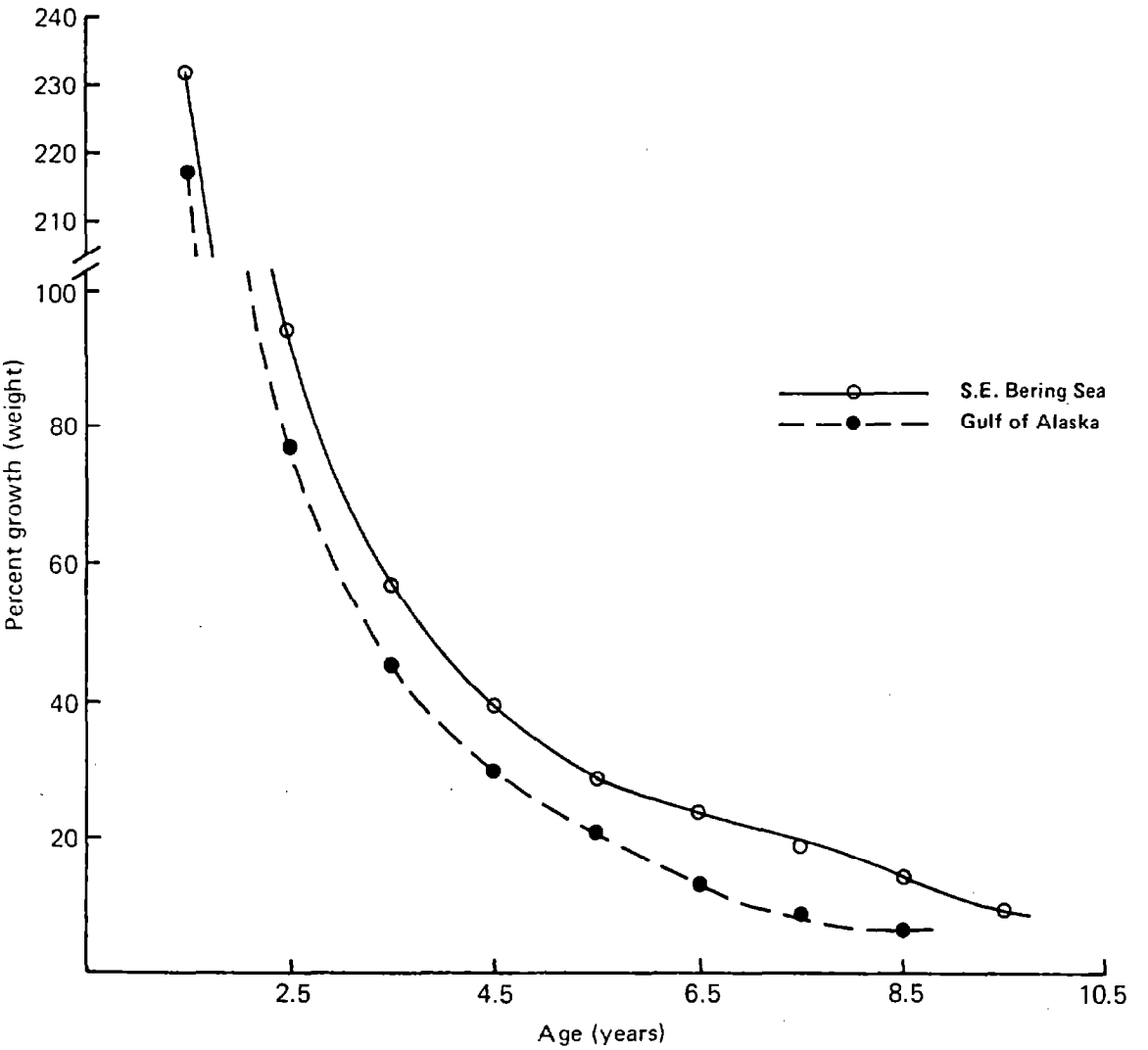



PACIFIC HERRING
Length-weight
400
350
300
250
200
150
100
50
Weight (g)
S.E. Bering Sea
Norton Sound
Gulf of Alaska
5
10
15
20
22.5
25
30
Length (cm)

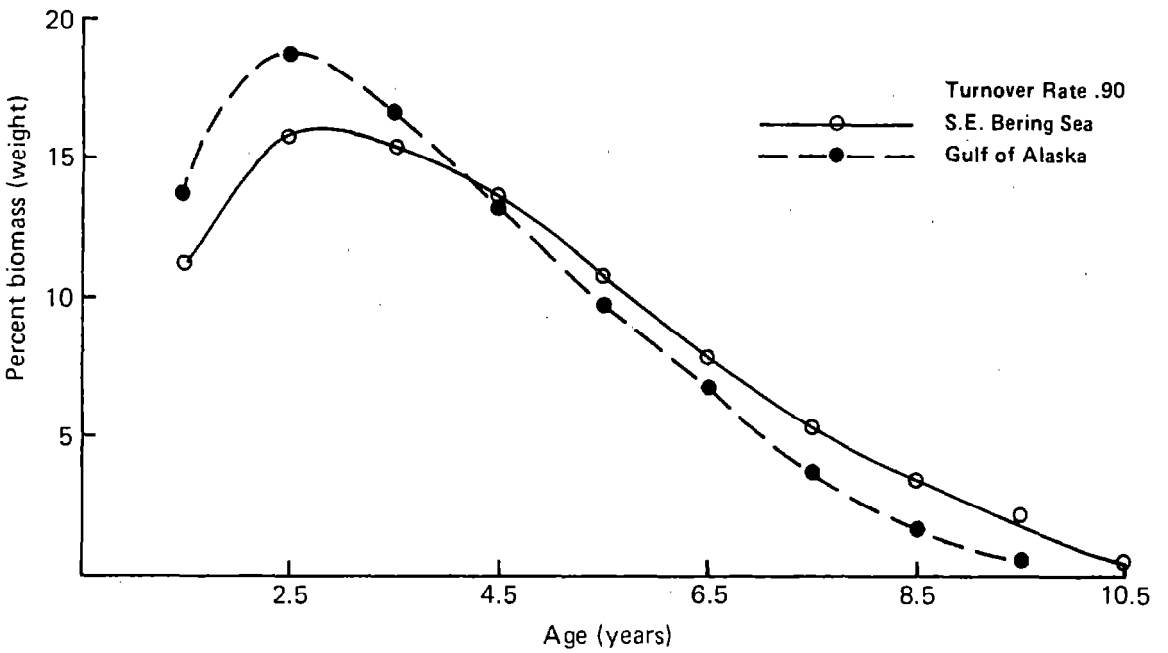
PACIFIC HERRING
Long term mean age composition of
fully exploited year classes



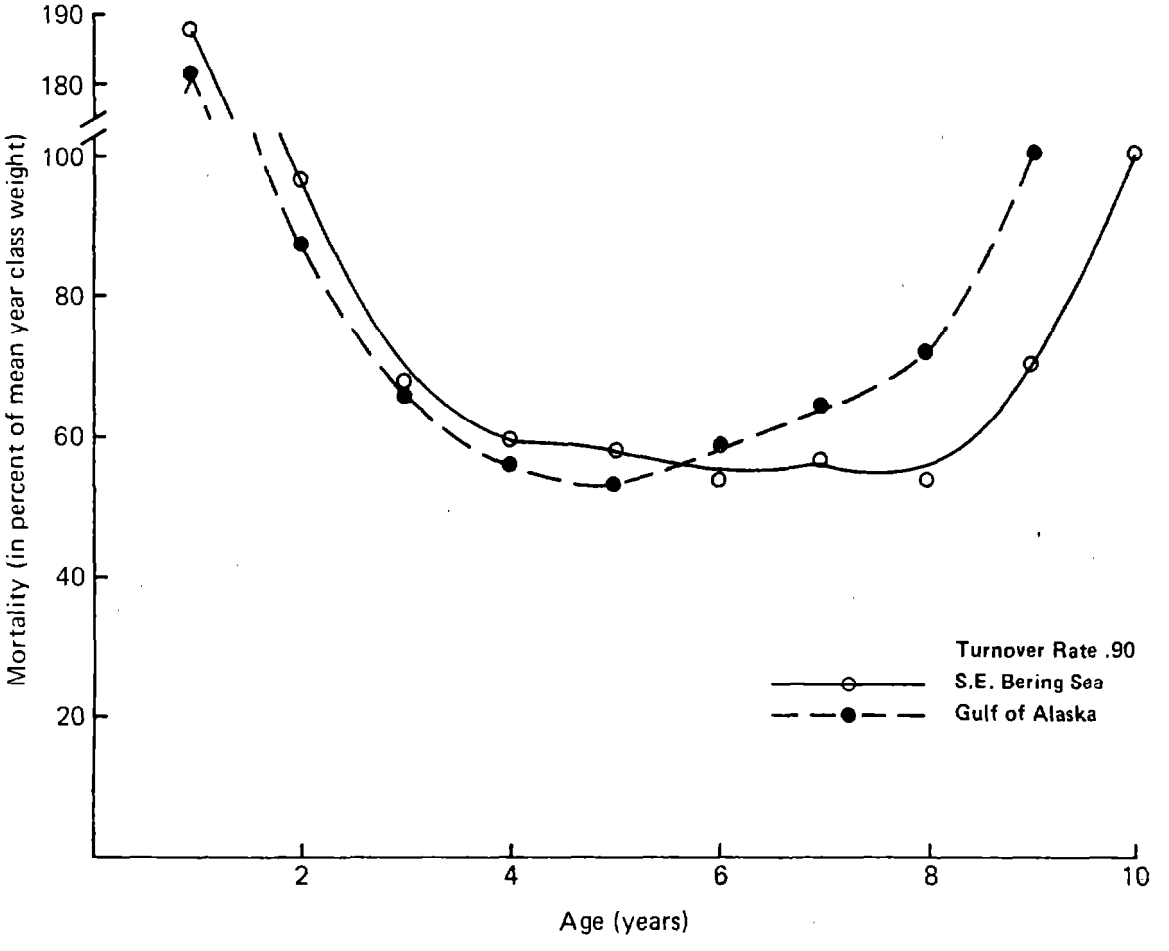
PACIFIC HERRING
Growth rate percent per year (weight)



PACIFIC HERRING
Distribution of,biomass with age



PACIFIC HERRING
Distribution of mortality with age



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